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Rules for the calculation of the Carbon Footprint of Electric Vehicle Batteries (CFB-EV)

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Abstract

This report provides the methodological guidelines for calculating the Carbon Footprint of batteries (CFB). It is based on the Environmental Footprint (EF) method developed by the European Commission (as in EC Recommendations 2279/2021) and Product Environmental Footprint Categories Rules for Batteries (PEFCR), and it provides detailed guidelines on methodological choices, modelling approaches, and documentation and verification requirements for the CFB. This work is supposed to provide the basis for the enforcement of requirements as in Article 7 of the Battery Regulation Proposal, supplementing the Regulation by establishing the methodology for calculation and verification of the carbon footprint of batteries.

The present report is targeting exclusively electric vehicle batteries as the first battery type to declare their CFB but will be the basis for developing also the corresponding CFB rules for all other battery types in scope of Article 7 of the Battery Regulation Proposal.

It is the result of extensive exchange with all involved stakeholders overall time period Q4/2021 - Q2/2023, including workshops and dedicated stakeholder consultations. As such, it represents the results of consensus building upon CFB modelling as proposed by various sources (including PEFCR and other LCA-based methods) and different positions among stakeholders for determining the CFB of EV batteries.

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We also acknowledge the detailed feedback received from all involved stakeholders, which helped to improve the rules under consideration of all different viewpoints, and which we tried to consider to the best extent possible. We also thank Recharge and the PEFCR-Technical Secretariat, particularly Claude Chanson, for the continous and fruitful exchange and continuous efforts for aligning methodologies. Finally, thanks also to all other colleagues from the EC that are not mentioned explicitly but contributed with valuable input and expertise, and the colleagues from DG-GROW and DG-ENV for support and input on policy developments and the Regulation text.

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Executive summary

This report provides the methodological guidelines for calculating the Carbon Footprint of batteries (CFB) for electric vehicle batteries, as required under Article 7 of the upcoming battery Regulation. It is based on the Environmental Footprint (EF) method developed by the European Commission (EC Recommendations 2279/2021)[1], the corresponding latest version of the PEF Data Guidelines[2], and the existing PEFCR for batteries[3] and its ongoing update. However, due to the specific scope and based on received feedback from stakeholders, some novel developments were introduced, in particular, on the definition of the functional unit, allocation, electricity and end-of-life modelling. This JRC report is conceived exclusively for EV batteries and not applicable to other types of batteries. For other battery types in scope of the Battery Regulation Proposal, separate studies will be conducted afterwards.

The report is comprised of nine sections, loosely following the structure of the EF method. Of those, six sections provide the main methodological guidelines, as briefly summarized in the following:

- Functional Unit (Section 3): The functional unit is defined as one kWh (kilowatt-hour) of the total energy provided by the battery over the battery's service life, measured in kWh. Different approaches are specified according to the vehicle type the battery is produced for. For light-duty EV and motorcycle batteries, the total energy is defined as the lifetime of the battery in km multiplied by the average energy demand for moving the vehicle one km. For heavy-duty EV and all other batteries, the total energy is defined as the number of full cycle equivalents provided by the battery multiplied by the energy provided over each cycle.
- System boundaries (Section 4): The system boundaries define the processes that have to be modelled for determining the CFB and those which shall be excluded. They comprise the whole life-cycle excluding the use stage, I.e., raw material acquisition and pre-processing, battery manufacturing and end-of-life. Specific cut-off rules are defined, with a general 1% (mass/mass) criterium per system component.
- Impact assessment (Section 5): Sets the life-cycle impact assessment methodology for quantifying the carbon footprint.
- Data collection requirements (Section 6): To allow a broad applicability to a different number of technologies, as required for the CFB Rules, two different types of processes are distinguished, as mandatory company-specific processes and non-mandatory company-specific processes. The formers comprise all processes where the use of company-specific data is mandatory as defined by the Regulation Proposal (active material and electrodes production, cell production, module and battery assembling). Non-company-specific processes are further subdivided into 'most relevant' processes and 'non-most relevant' processes. Only for the former (most relevant), the development of own, company-specific datasets is allowed for upstream processes, while for all non-most relevant data, the use of secondary datasets is mandatory. With this approach, the use of the Data Needs Matrix is avoided (deemed not suitable for the products in scope of these CFB Rules) and the modelling simplified substantially. The mandatory use of secondary datasets increases comparablity and relieves the notified body from verifying an unforeseeable amount of datasets. Also, the data quality requirements have been revised to allow considering the adjustment of the geographical scope of partially aggregated datasets in the overall data quality rating (DQR).
- Modelling requirements (Section 7): Provides rules for the modelling of specific aspects of the CFB model, such as electricity modelling, allocation, and end-of-life modelling. Updates regarding the original EF methods have been made for electricity modelling, where stricter requirements have been set, including a physical connection for electricity exchange via power purchase agreements and the elimination of credits for excess on-site generated electricity. The CFF (circular footprint formula) has been updated according to the needs of the CFB, where the impacts of the battery cell recycling are not material-specific, but occur for the battery as a whole, requiring a modification of the CFF to avoid the mandatory allocation of recycling

[1] EC, Commission Recommendation (EU) 2021/2279 of 15 December 2021 on the use of the Environmental Footprint methods to measure and communicate the life-cycle environmental performance of products and organisations, 2021. Available at https://eur-lex.europa.eu/eli/reco/2021/2279/oj.

[2] Simone Fazio, Luca Zampori, An De Schryver, Oliver Kusche, Lionel Thellier, Edward Diaconu. Guide for EF compliant data sets: Version 2.0, EUR 30175 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-17951-1, doi:10.2760/537292, JRC120340. Available at https://eplca.jrc.ec.europa.eu/permalink/Guide_EF_DATA.pdf

[3] Recharge, PEFCR - Product Environmental Footprint Category Rules for High Specific Energy Rechargeable Batteries for Mobile Applications, 2020.

process burdens to the recovered materials. Also, the collection rate has been introduced as an explicit parameter to account for the fact that not all batteries are actually collected for proper recycling but undergo scavenging and unknown end-of-life treatments.

- Verification (Section 8): Comprises all requirements regarding documentation and verification of the CFB. Two different formats are defined for verification, a public CFB supporting study where the CFB result and some selected key values have to be disclosed, as required for transparency and comparability. The non-public version of the CFB supporting study is extensive and contains all modelling assumptions, detailed data collection tables, and justifications of all modelling assumptions taken for developing the CFB. This part is confidential and accessible only by the notified body for the verification process.

Finally, the Annexes provide some more detailed guidelines on data collection and provide standard templates for data collection, ensuring that all collected data are provided with the relevant information of verification. In addition, default activity data are provided for the battery cell recycling processes that shall be used if no company-specific modelling is done.

The present report is the result of extensive exchange with all involved stakeholders over a time period of 1.5 years (from Q4/2021 to Q2/2023), including workshops and dedicated stakeholder consultations. All received feedbacks have been analysed and considered when deemed appropriate for the final version of the CFB. As such, the present report represents the outcome of a consensus building process on CFB based on different available life-cycle based sources and various position from different stakeholder.

1 Introduction

The European Union aims at being carbon neutral by 2050[4,5] and has implemented several legislations to support this transition and the sustainable development of new technologies.

Batteries are a strategic enabler to face several challenges of the current society, such as green mobility, green energy, and climate neutrality, as demonstrated by the increasing demand for batteries in several sectors. In the European Green Deal, the Commission already presented its commitment to propose legislation to ensure a safe, circular, and sustainable value chain for all batteries, including the supply of the growing market of electric vehicles. In this regard, the Battery Regulation Proposal establishes a harmonized legal framework to address the entire life-cycle of batteries and provides a legal certainty to all the operators working in the supply-chain by including uniform product requirements, conformity assessment procedures, and end-of-life requirements to support the recycling market.

The Battery Regulation Proposal is currently composed of 79 articles and 14 Annexes and sets some rules on sustainability parameters, performance, safety, collection, recycling, and second life of batteries as well as on information requirements about batteries. One of the sustainability parameters to be calculated and communicated is the carbon footprint of the batteries (CFB) specified in Article 7 of the same Regulation Proposal. The CFB quantifies the total amount of greenhouse gases as g CO_2 equivalent per one kWh of the total energy provided by the battery over its expected service life. The CFB shall be declared for "rechargeable industrial batteries with a capacity above 2 kWh, light means of transport (LMT) batteries and electric vehicle (EV) batteries placed on the Union market". CFB declarations will then be used to define the CFB performance classes and CFB thresholds that batteries entering the European market should comply with. Ultimately, this Regulation will ensure that the expected massive deployment of batteries (e.g., in mobility) will be associated with minimum overall carbon emissions. The CFB shall accompanied by a public version and a non-public version of the CFB supporting study.

The development of the CFB shall be in line with elements included in the Annex II of the Battery Regulation Proposal and building on methodological aspects as in the latest version of the European Commission's Environmental Footprint (EF) method (as in the EC Recommendation 2021/2279[6]) and relevant Product Environmental Footprint Category Rules (PEFCRs). Also, technical/scientific progress in the area of life-cycle assessment (e.g., to what concern life-cycle impact assessment) should be reflected.

The Joint Research Centre (JRC) of the European Commission has been in charge for providing technical support to the development of the secondary legislation on the CFB (in line with the requirements of the article 7 and Annex II of the Battery Regulation Proposal). To develop these rules, the JRC organised two workshops (one in 2021 and one in 2022) and one stakeholder consultation (in February 2023) to present and discuss different methodological options to stakeholders.

For the drafting of the present document, the Battery Regulation Proposal version of the 18th of January 2023[7] has been considered as the reference policy document. Article 7(1) of the Battery Regulation Proposal states that the CFB declaration will apply in different moments to EV batteries, rechargeable industrial batteries excluding those with exclusively external storage, LMT batteries, and rechargeable industrial batteries with external storage. CFB declaration will apply first to EV batteries "18 months after entry into force of the Regulation or 12 months after the entry into force either of the delegated act or of the implementing act". The present JRC report suggests possible CFB rules for EV batteries, as further specified in Section 2.

NOTE: The text of carbon footprint rules has been kept as concise as possible. All sections specified as "NOTE" have to be considered as explicative to the text and not be intended as part of the rules for Carbon Footprint of Batteries (CFB).

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4 EC, The European Green Deal, COM/2019/640, 2019. Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2019%3A640%3AFIN .

5 EC, A Clean Planet for all - A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy, COM (2018) 773, 2018. Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52018DC0773 .

6 EC, Commission Recommendation (EU) 2021/2279 of 15 December 2021 on the use of the Environmental Footprint methods to measure and communicate the life-cycle environmental performance of products and organisations, 2021. Available at https://eur-lex.europa.eu/eli/reco/2021/2279/oj.

7 EU, 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, 2023. Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=consil:ST_5469_2023_INIT

Unless otherwise specified in this document, the EF method as in the EC Recommendation 2021/2279 shall be considered as general guidelines about how to determine the carbon footprint.

1.1 Terminology

This report uses the following terminology to indicate the requirements, as:

- The term "shall" is used to indicate what is required in order to calculate the CFB.
- The term "may" is used to indicate an option that is permissible. Whenever options are available, the CFB supporting study shall include adequate argumentation and evidence to justify the chosen option.

2 Scope

The CFB shall be declared for any EV battery that falls within the scope of Article 7 of the Battery Regulation Proposal, independent of its cell chemistry and of the actual service it will provide within the specific application. The scope of the CFB excludes batteries that have been subject to preparing for re-use, preparing for repurpose or repurposing, or remanufacturing, if the batteries had already been placed on the market or put into service before undergoing such operations (according to the Article 7 (point 3b) of the Battery Regulation Proposal).

NOTE: Even if currently the most common chemistry for EV batteries is lithium-ion, the CFB rules for EV set out in the present document are as general as possible to be applicable also to other chemistries or to chemistries under development. The CFB rules could be updated in future to address more precisely specific aspects of emerging chemistries (e.g., Mg-S, Aluminium) especially once they achieve market maturity. Similar considerations apply to emerging anode/cathode materials for any of the possible battery chemistries and to other battery technologies.

3 Functional Unit and Reference Flow

3.1 Functional unit for energy-providing batteries

For energy-providing batteries such as EV batteries, the **functional unit** is defined (according to the Annex II of the Battery Regulation Proposal) as one kWh (kilowatt-hour) of the **total energy** provided by the battery over the battery's **service life**, measured in kWh.

The **total energy** (in kWh) is the total amount of electricity (in kWh) provided by the battery over its service life.

Four different approaches are used for quantifying the total energy provided over the service life by EV batteries, depending on the considered vehicle category:

- Light-duty EV batteries
- Category L (Motorcycle) EV batteries
- Medium-duty and heavy-duty EV batteries
- Other EV batteries

Additional services (e.g., fast charging, extended temperature range) are considered as secondary functions and shall not be measured in the functional unit. Information related to additional services may be separately disclosed in the CFB supporting study, including the type of additional service provided and related standards (if any), and the environmental impact that may be associated to these additional services.

3.1.1 Light-duty EV batteries

For light-duty electric vehicle batteries (vehicles belonging to categories M1 and N1 in the meaning of the Regulation (EU) 2018/858[8]), the total energy shall be calculated by multiplying (a) the service life (expressed in km) with (b) the energy discharged from the battery per unit of distance driven (expressed in kWh/km) measured during the type approval test.

NOTE: EV batteries installed in the following vehicle types (as defined in UN GTR No. 15, namely Worldwide harmonised Light vehicles Test Procedure or WLTP[9]) fall under this calculation method: pure electric vehicles (PEVs), off-vehicle charging hybrid electric vehicles (OVC-HEVs, also known as plug-in hybrid electric vehicles), not off-vehicle charging hybrid electric vehicles (NOVC-HEVs, also known as non-plug-in hybrid electric vehicles), and EV batteries installed in fuel cell hybrid vehicles (FCHVs) that are used for traction purposes.

The service life is defined as the number of km driven until the battery reaches a State of Certified Energy (SOCE) equal to 70% for category M1 vehicles and equal to 65% for category N1 vehicles (as specified in the Annex II of the Commission's Proposal for Euro 7[10]). The SOCE is defined as the percentage of the certified (useable) battery energy remaining at a given point in time, monitored by the Battery Management System (BMS), according to UN GTR No. 22. The default service life is assumed to be 160,000 km, according to the UN GTR No. 22[11] minimum performance requirements (MPRi).

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8 REGULATION (EU) 2018/858 of the European Parliament and of the Council of 30 May 2018 on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles, amending Regulations (EC) No 715/2007 and (EC) No 595/2009 and repealing Directive 2007/46/EC, 2018, OJ (L 151), p. 1–218 Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32018R0858#:~:text=Regulation%20(EU)%202018%2F858,No%20595%2F2009%20and%20repealing.

9 United Nation Global Technical Regulation (UN GTR) No. 15: Worldiwide harmonised Light vehicles Test Procedure (WLTP), 2021. Available at https://unece.org/sites/default/files/2022-06/ECE-TRANS-180a15am6e.pdf

10 European Commission, Annex to the Proposal for a Regulation of the European Parliament and of the Council on type-approval of motor vehicles and engines and of systems, components and separate technical units intended for such vehicles, with respect to their emissions and battery durability (Euro 7) and repealing Regulations (EC) No 715/2007 and (EC) No 595/2009, 2022, COM/2022/586 final. Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022PC0586.

11 UNECE, UN GTR No.22 (In-vehicle Battery Durability for Electrified Vehicles), 2022, available at https://unece.org/sites/default/files/2022-04/ECE_TRANS_180a22e.pdf.

NOTE: The minimum battery's service life is assumed to be 160,000 km (applying the same SOCE values for the end-of-life) also for NOVC-HEVs even if they are not included in the scope of the UN GTR No. 22. In fact, the minimum service life is also defined as a vehicle minimum durability requirement in UN Regulation No. 154[12]*, as well as in the Annex IV of the Commission's Proposal for Euro 7.*

The CFB declarant may declare a higher service life (expressed in km), providing documentation in support of the claim in the CFB supporting study. The declaration of a higher service life shall be expressed in number of km driven until the battery reaches a SOCE equal to 70% for category M1 vehicles and equal to 65% for category N1 vehicles. The declared service life and the corresponding total energy shall be consistent with the expected lifetime in terms of full cycles equivalents (as to be declared according to Annex IV of the Battery Regulation Proposal) and with the SOCE and total energy throughput values to be read from the BMS according to Annex II of the UN GTR No. 22.

The delivered energy (in Wh/km) is defined as the energy discharged from the battery (expressed in Wh), directly measured while performing the WLTP type approval tests (type I), divided by the applicable WLTP test distance (expressed in km). The delivered energy shall be provided with a minimum precision of 0.1 Wh/km. Specific provisions for performing these measurements and calculations are defined in Section 3.3 of this document and in Annex 8 of UN Regulation No. 154 and its following amendments[13]. Interpolation families as defined in UN Regulation No. 154 may be used for the determination of the delivered energy. If an interpolation family is used, the delivered energy shall be measured for the vehicle configuration with the lowest energy consumption inside the same interpolation family (namely "vehicle low"). If the same battery is used in two or more different vehicle interpolation families, the CFB shall be calculated for each interpolation family and the highest CFB value shall then be used for the battery (corresponding to the lowest energy consumption amongst the different interpolation families). In any case, M1 vehicles (performing the function of passenger transport) and N1 vehicles (performing the function of goods transport) shall not be aggregated into the same vehicle interpolation family, meaning that if the same battery is used in both M1 vehicles and N1 vehicles, two different CFB declarations are required.

NOTE: It is not possible to aggregate M1 vehicles and N1 vehicles in the same interpolation family because these two vehicle categories have a different service life definition (i.e., different end-of-life SOCE).

Both the service life and the delivered energy used for the calculation of the functional unit shall be reported in the CFB supporting study.

NOTE: The UN GTR No. 22 is a Global Technical Regulation that aims at providing "a worldwide harmonized method to set and verify minimum performance requirements on in-vehicle battery durability of Pure Electric Vehicles (PEVs) and Off-Vehicle Charging Hybrid Electric Vehicles (OVC-HEVs)". The UN GTR No. 22 states that the manufacturers have to install systems that monitor the SOCE (State of Certified Energy) and SOCR (State of Certified Range) during the life of the vehicle. The battery durability requirements define that the vehicle battery shall reach a minimum value of SOCE and SOCR at different specific points in the lifetime of the vehicles. The minimum values depend on the type of vehicle. For example, one of the Minimum Performance Requirements (MPRi) for Vehicle categories 1-1 and 1-2 in the scope of the GTR states that the SOCE shall be at least 80% after 100,000 km or 5 years and 70% after 160,000 km or 8 years. Higher values of SOCE may be declared as Declared Performance Requirement (DPRi).

NOTE: The possibility to declare a higher service life than 160,000 km is consistent with the Annex II and Annex IV of the Commission's Proposal for Euro 7.

[12] UN Regulation No 154 – Uniform provisions concerning the approval of light duty passenger and commercial vehicles with regards to criteria emissions, emissions of carbon dioxide and fuel consumption and/or the measurement of electric energy consumption and electric range (WLTP) [2022/2124], 2022, OJ (L 290), p. 1–625. Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2022.290.01.0001.01.ENG

[13] UN Regulation No 154 – Uniform provisions concerning the approval of light duty passenger and commercial vehicles with regards to criteria emissions, emissions of carbon dioxide and fuel consumption and/or the measurement of electric energy consumption and electric range (WLTP) [2022/2124], 2022, OJ (L 290), p. 1–625. Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2022.290.01.0001.01.ENG

3.1.2 Category L (Motorcycle) EV batteries

For EV batteries integrated into vehicles of category L in the meaning of the Regulation (EU) No. 168/2013[14], the total energy (in kWh) shall be calculated by multiplying (a) the service life (expressed in km) with (b) the delivered energy (in kWh/km) determined according to type approval test.

Given the current lack of battery durability standards (e.g., similar to UN GTR No. 22 for light-duty vehicles) for L-category vehicles, the service life is defined as the battery lifetime, assumed to be equal to the vehicle lifetime as declared by the manufacturer. Documentation on the lifetime mileage and on the main assumptions used for its definition (e.g., assumed SOCE at the end-of-life) shall be provided in the CFB supporting study. The corresponding total energy shall be consistent with the expected lifetime in terms of full cycle equivalents (as to be declared according to Annex IV of the Battery Regulation), and the SOCE at the end of the battery's life shall correspond to the end-of-life SOCE used in the lifetime test according to Annex IV of the Battery Regulation.

NOTE: The definition of the service life of EV batteries installed in vehicles of category L might be updated when a standard on battery durability will be available.

The delivered energy in kWh/km is defined as the electric energy consumption derived from type approval test, according to WMTC (Worldwide Harmonised Motorcycle Testing Cycle) as defined by the UNECE Global Technical Regulation No. 2[15], and by the methods specified in Annex VII, Appendix 2 of the Regulation (EU) 134/2014[16]. The energy consumption shall be reported in the CFB supporting study with a minimum precision of 0.1 Wh/km.

3.1.3 Medium-duty and heavy-duty EV batteries

For EV batteries installed in medium-duty and heavy-duty vehicles (categories M2, M3, N2 and N3 in the meaning of the Regulation (EU) 2018/858) the total energy shall be calculated by multiplying (a) the service life (expressed in number of full cycles equivalents) with (b) the battery energy capacity.

The service life is defined as the total number of full equivalent discharge cycles (i.e., from 100% SoC to 0% SoC until the end-of-life of the battery) as declared by the CFB declarant, equivalent to the expected lifetime in terms of cycles as to be declared according to Annex IV of the Battery Regulation Proposal. Documentation in support of the claim (declared lifetime, total energy throughput and methods / standards used for determining it) shall be provided in the CFB supporting study.

The battery energy capacity is calculated as the rated capacity (expressed in "Ah", according to Annex IV of the Battery Regulation Proposal) multiplied by the nominal voltage (expressed in "V", according to Annex XIII of the Battery Regulation Proposal). This parameter corresponds to the full dischargeable electrical energy (expressed in kWh), from 100% State of Charge (SoC) to 0% SoC, at Beginning of Life (BoL).

NOTE: The definition of the service life of EV batteries installed in medium-duty and heavy-duty vehicles might be updated once the UN-GTR for battery durability in medium-duty and heavy-duty vehicles will be in place.

3.1.4 Other EV batteries

For EV batteries belonging to category O in the meaning of the Regulation (EU) 2018/858 and for all other EV batteries under Article 7 of the Battery Regulation Proposal not falling under the previous cases, the total energy (in kWh) shall be calculated by multiplying (a) the service life in cycles with (b) the average amount of delivered energy over each cycle.

The service life is defined as in Article 10 Annex IV of the Battery Regulation Proposal as the expected lifetime under the reference conditions for which they have been designed in terms of cycles.

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[14] Regulation (EU) No 168/2013 of the European Parliament and of the Council of 15 January 2013 on the approval and market surveillance of two- or three-wheel vehicles and quadricycles Text with EEA relevance, 2013, OJ (L 60), p. 52–128. Available at https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32013R0168.

[15] United Nations Global Technical Regulation No. 2 on the measurement procedure for two-wheeled motorcycles equipped with a positive or compression ignition engine with regard to the emissions of gaseous pollutants, CO2 emissions and fuel consumption. Available at https://unece.org/fileadmin/DAM/trans/main/wp29/wp29wgs/wp29gen/wp29registry/ECE-TRANS-180a2am4e_for_submission.pdf.

[16] Commission Delegated Regulation (EU) No 134/2014 of 16 December 2013 supplementing Regulation (EU) No 168/2013 of the European Parliament and of the Council with regard to environmental and propulsion unit performance requirements and amending Annex V thereof Text with EEA relevance, 2014, OJ (L 53), p. 1–10. Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014R0134.

The average amount of delivered energy over each cycle is equivalent to the rated energy capacity of the battery multiplied by the average discharge depth during each cycle of the cycle life test and by the medium value between initial SOCE (100%) and end-of-life SOCE. The average amount of delivered energy over each cycle shall be calculated as the "rated capacity (expressed in “Ah”, acc. to Annex IV of the Battery Regulation Proposal) multiplied by (i) the nominal voltage" (expressed in “V” according to Annex XIII of the Battery Regulation Proposal), (ii) the number of full cycle equivalents (according to Annex IV), and (iii) the average depth of discharge (DoD) between 100% SoH (or SOCE if available) and end-of-life SoH (or SOCE if available).

Both the service life and the average amount of delivered energy over each cycle used for the calculation of the functional unit shall be reported in the CFB supporting study.

NOTE: The service life definition might be updated when a CEN/CENELEC standard for the expected lifetime will be developed.

3.2 Reference flow

For all the batteries in the scope of these CFB Rules, the reference flow is the amount of product needed to fulfil the defined function and shall be measured in kg of battery per functional unit. All quantitative input and output data collected by the CFB declarant to quantify the carbon footprint shall be calculated in relation to this reference flow.

The reference flow is calculated as the total mass of battery divided by the quantity of functional unit.

3.3 Calculation of discharged battery energy per km for light-duty vehicles

The discharged battery energy of light-duty vehicles shall be calculated by means of an integral of the voltage and current, both directly measured over time while performing the WLTP type approval tests. In order to measure the battery output, only the current flows going out from the battery (in direct current, DC) shall be taken into account.

NOTE: the calculation of the discharged battery energy is defined similarly to what is provided in UN Regulation No. 154 in Annex B8, Paragraph 4.3, but taking into account specific provisions useful for the purpose of calculating the functional unit for the CFB declaration.

For the determination of the discharged electric energy based on the current and voltage measurements, the following equations shall be used:

$$DE_{DC,\,j} = \frac{\Delta E_{Discharge,\,j}}{d_j}$$

where:

$DE_{DC,\,j}$ is the delivered electric energy per unit of distance over the considered period j based on the energy discharged from the battery (Wh/km);

$\Delta E_{Disch\arg e,\,j}$ is the electric energy discharged from the traction battery during the considered period j (Wh);

d_j is the distance driven in the considered period j (km).

$\Delta E_{Disch\arg e,\,j}$ shall be calculated as following:

$$\Delta E_{Discharge,\,j} = \frac{1}{3600} \times \int_{t_0}^{t_{end}} U(t)_{Batt,\,j} \times I(t)_j \, dt$$

Where:

$U(t)_{Batt,\,j}$ is the voltage of the battery (in function of time) during the considered period j determined according to voltage measurements (in V);

$I(t)_j$ is the electric current of battery (in function of time) during the considered period j determined according to current measurements (in A);

t_0 is the time at the beginning of the considered period j (s);

t_{end} is the time at the end of the considered period j (s);

j is the index for the considered period, where a period can be any combination of phases or cycles;

$\frac{1}{3600}$ is the conversion factor from “Ws” to “Wh”.

The procedure for determining the required battery performance parameters is the following:

- Voltage (U) measurement: Voltage measurements shall be performed as defined in UN Regulation No. 154 in Annex B8, Appendix 3, Paragraph 3.1 (External REESS voltage measurement). As a specific provision for the purpose of this calculation, the Table A8 App3/1 in UN Regulation No. 154, Annex B8, Appendix 3 is amended as follows: nominal voltage shall be avoided and instead measured voltage in function of time (as defined in paragraph 3.1) shall always be used (e.g. even for NOVC-HEVs and OVC-HEVs in charge sustaining conditions)
- Current (I) measurement: Current measurements shall be performed as defined in UN Regulation No. 154 in Annex B8, Appendix 3, Paragraph 2.1 (External REESS current measurement)
- Calculation of discharged battery energy: Discharged battery energy shall be calculated as defined in UN Regulation No. 154 in Annex B8, Paragraph 4.3, with additional specific provisions and amendments provided in this section. Only “t” values with negative current (battery discharge) shall be integrated
- Calculation of discharged battery energy per km: Calculation shall be performed by dividing the energy discharged from the battery by the applicable WLTP test distance (expressed in km)

All these measurements and calculations shall be reported in the CFB supporting study.

4 System Boundaries and cut-off rules

The system boundaries define which parts of the product life-cycle and which associated life-cycle stages and processes belong to the analysed system (i.e., are required for carrying out its function as defined by the functional unit).

The definition of the system boundaries follows a general supply-chain logic, including all stages from raw material acquisition and pre-processing, production of the main product, product distribution, etc.

The following life-cycle stages shall be included in the system boundaries (Figure 1):

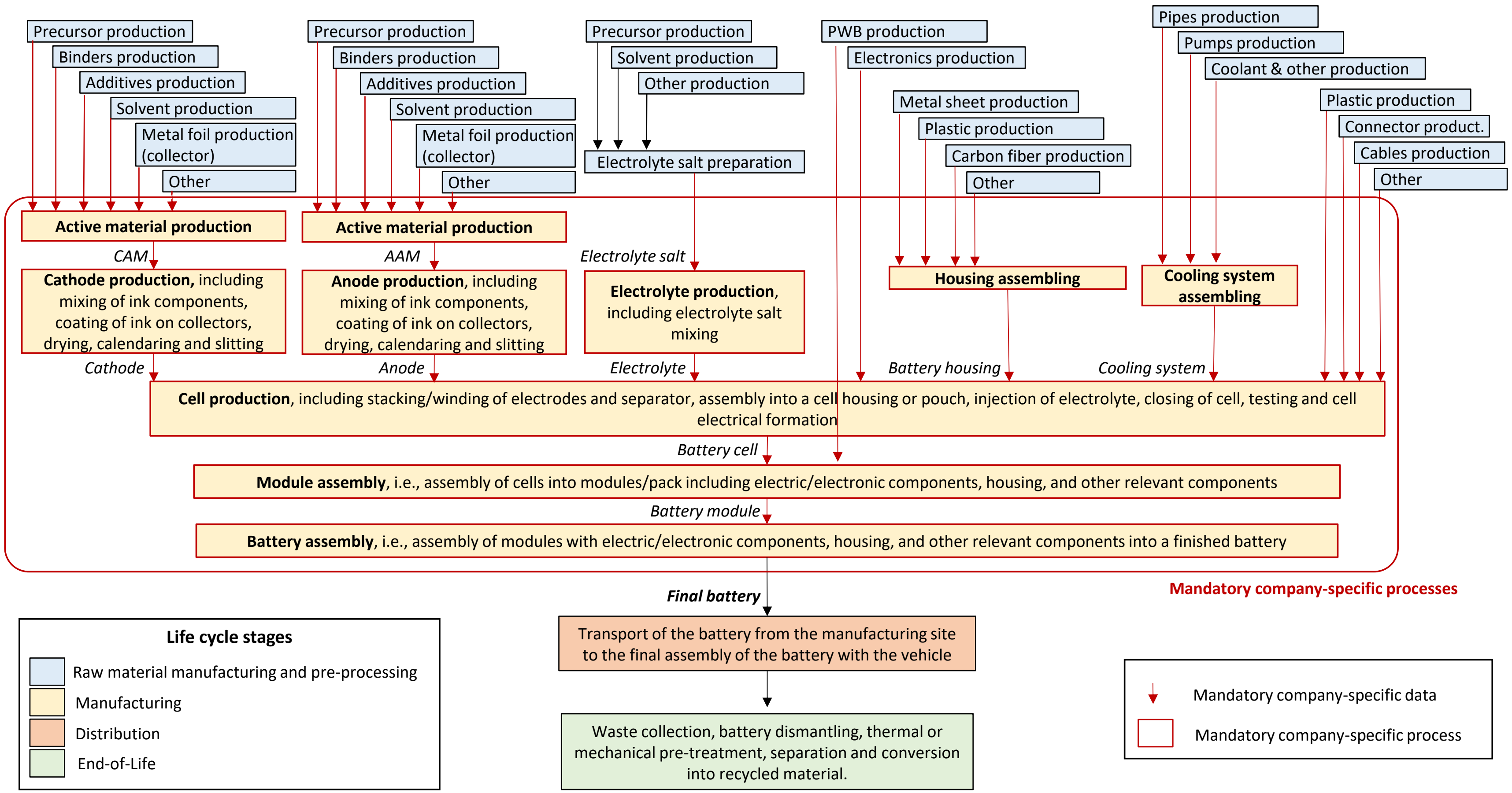
— 'Raw materials acquisition and pre-processing', described in section 4.2.

— 'Manufacturing' of the battery, described in section 4.3.

— 'Distribution', described in section 4.4.

— 'End-of-life', described in section 4.5.

Figure 1. System boundaries of the carbon footprint of a generic EV battery. Other types of batteries (e.g., anode-free batteries, cell-to-pack design) may have a different visualization of their system boundaries. Each square represents a process, while each arrow represents an activity data (e.g., kg of solvent, kg of additive). The different colours (blue, yellow, orange, and green) indicates in which life-cycle stage each process belongs, while red arrows and red borders indicates if a process/activity data shall be company-specific (section 6.1). PWB: Printed Wiring Board. CAM: cathode active material, AAM: anode active material.



Source: JRC

4.1 Cut-off rules

The following processes shall be excluded from the modelling:

- The use-phase according to Article 7 and Annex II of the Battery Regulation Proposal.
- Manufacturing of equipment (capital goods), as impacts have been calculated as negligible according to the Product Environmental Footprint Category Rules (PEFCR) for batteries[17].
- The installation of the finished battery in the battery electric vehicle by the vehicle manufacturer (OEM) since the specific energy or material consumption are negligible compared to the manufacturing process of the components according to the Annex II of the Battery Regulation Proposal.
- The production of packaging materials, as the contribution to the overall impact has been estimated to be negligible according to the Product Environmental Footprint Category Rules (PEFCR) for batteries.
- Any part of the cooling system not physically contained in or permanently attached to the housing.
- Auxiliary inputs to the manufacturing plant that are not directly related to the battery production process (such as heating and lighting of associated office rooms, secondary services, sales processes, administrative and research departments, etc.).

NOTE: the auxiliary inputs to the 'Manufacturing' life-cycle stage were estimated to be negligible: assuming a consumption of a generic office as 293 kWh/m^2 [18], and assuming a production area of 267,000 m^2 (compatible with a facility of 20 GWh/year of production capacity), the auxiliary energy consumption is estimated to be about 0.2% of the electrical energy required by the production line.

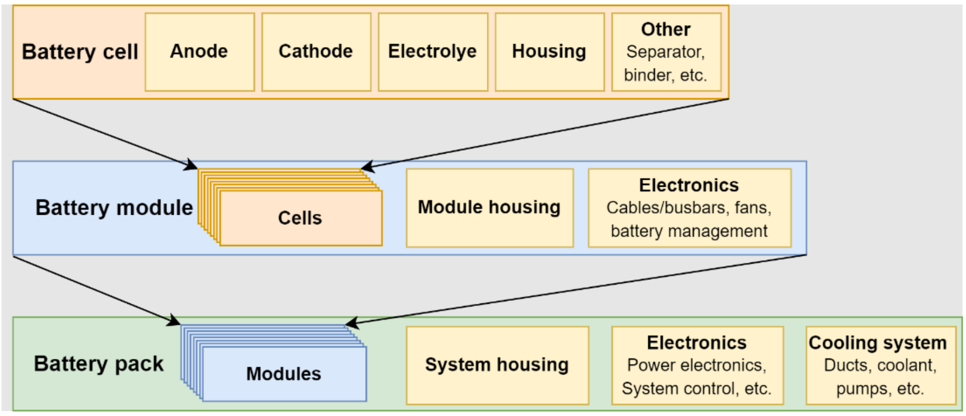
- Storage operations during the 'Distribution' life-cycle stage.
- The impacts of the collection of the battery waste, the impacts of the pre-treatment of the waste batteries (e.g., extraction from vehicle, discharge, sorting), the impacts of the dismantling of the battery and its component, and the transport during the 'End-of-life' life-cycle stage.

Furthermore, a general cut-off of 1% in mass may be applied to material inputs per system component as in Figure 2 (e.g., it is possible to neglect input and output flows of the housing that make up less than 1% to the total mass of the housing). To close the mass balance, the missing mass shall be added to the input of the same system components with the highest specific carbon footprint. The CFB-declarant shall report in the CFB supporting study if and where the cut-off of 1% in mass has been applied.

[17] Recharge, PEFCR - Product Environmental Footprint Category Rules for High Specific Energy Rechargeable Batteries for Mobile Applications, 2020.

[18] Luis Pérez-Lombard, José Ortiz, Christine Pout, A review on buildings energy consumption information, Energy and Buildings, Volume 40, Issue 3, 2008, Pages 394-398, ISSN 0378-7788, https://doi.org/10.1016/j.enbuild.2007.03.007.

Figure 2. System components. The inner boxes depict the individual components of each product e.g., the battery cell comprises the components 'anode', 'cathode', 'electrolyte', 'housing' and 'other', while the components of the battery module are 'cells', 'housing' and 'electronics'.



Source: JRC

4.2 Raw material acquisition and pre-processing

The 'Raw material acquisition and pre-processing' life-cycle stage covers the extraction of resources from nature and their pre-processing until their use in product components entering (through the gate of) the battery's production facility, as described in the system boundaries (Figure 1). Transport of raw materials and intermediate products within and between extraction and pre-processing facilities until the battery manufacturing plant shall be included in this life-cycle stage. This life-cycle stage includes, for example, the production of the solvents for the electrolyte salt, the pipes and the coolant for the cooling system, etc.

4.3 Manufacturing

EV batteries are usually comprised of several battery cells grouped together forming a battery. Given the wide range of applications these systems are designed for, they may come in very diverse layouts and system configurations. Typically, several battery cells are grouped together to form battery modules, which are then mounted together in a specific structure to form a battery pack for electric vehicles. A schematic representation of the considered system components is provided in section 4.1. The final battery comprises all components that are contained in or attached to the battery housing.

The 'Manufacturing' life-cycle stage includes:

- Anode and cathode active material production.
- Anode and cathode production, including the mixing of ink components, coating of ink on collectors, drying, calendaring, and slitting.
- Electrolyte production, including the electrolyte salt mixing.
- Housing and cooling system assembling.
- Cell production (i..e, the assembly of cell components into a battery cell), including stacking/winding of electrodes and separator, assembly into a cell housing or pouch, injection of electrolyte, injection of the electrolyte, closing of cell, testing and electrical formation.
- Module assembling, i.e., assembly of cells into modules/pack including electric/electronic components, housing, and other relevant components.
- Battery assembly, i.e., assembly of modules with electric/electronic components, housing, and other relevant components into a finished battery
- All transport operations of the final and intermediate products to the site where they are used.

More information on how to account for manufacturing scraps and recycled content in the 'Manufacturing' life-cycle stage is provided in section 7.3.

4.4 Distribution

The 'Distribution' stage considers the transport of the battery from the manufacturing site to the final assembly of the battery within the vehicle (i.e., the OEM manufacturing plant where the battery is assembled with the vehicle).

4.5 End-of-life

The 'End-of-life' life-cycle stage begins when the product in scope (or the EV where the battery is incorporated) is disposed of or discarded by the user and ends when the product in scope is returned to nature as a waste product or enters another product's life-cycle (i.e., as a recycled input). On the other hand, waste generated during the 'Raw material acquisition and pre-processing' and 'Manufacturing' life-cycle stages shall be included in the life-cycle of the product and modelled at the life-cycle stage where it occurs.

The 'End-of-life' life-cycle stage includes:

- Battery waste collection
- Battery dismantling
- Thermal or mechanical pre-treatment (e.g., milling of the battery cell)
- Separation and conversion into recycled material (e.g., pyrometallurgical and hydrometallurgical treatment).

— Energy recovery and disposal.

More information on how to model the ‘End-of-life' life-cycle stage is provided in section 7.3.

5 Impact Assessment

The impact assessment shall be done for the impact category "Climate change" using the EF3.1 impact assessment method[19] and be reported in g CO_2 eq/kWh.

NOTE: The EF3.1 "Climate change" is in line with the Sixth Assessment Report (AR6) of the IPCC2021[20].

[19] EC, Developer Environmental Footprint (EF), 2023. Available at https://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml.

[20] Forster, P., T. Storelvmo, K. Armour, W. Collins, J. L. Dufresne, D. Frame, D. J. Lunt, T. Mauritsen, M. D. Palmer, M. Watanabe, M. Wild, H. Zhang, 2021, The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press. - Available at https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter_07.pdf

6 Inventory data – Data collection requirements and quality requirements

A CFB model is composed of processes that combine elementary flows with the corresponding characterisation factors, and activity data with the corresponding life-cycle inventory or carbon footprint of the underlying process.

Both data (i.e., activity data and elementary flows) from processes and the underlying sub-processes can be company-specific or secondary (i.e., taken from databases). The CFB Rules distinguish between mandatory company-specific processes (section 6.1) and non-mandatory company-specific processes (section 6.2).

6.1 Mandatory company-specific processes

A mandatory company-specific process is a process for which all data (i.e., activity data and elementary flows) shall be company-specific[21] and shall refer to a specific battery model produced in a specific manufacturing plant.

All the processes in the "Manufacturing" life-cycle stage are mandatory company-specific processes (see Figure 1): cathode and anode active material production, cathode and anode production, electrolyte production, housing assembling, cooling system assembly, cell production, module assembly, and battery assembly. If the active material is equivalent to the active material precursor (such as in the case of natural graphite, hard carbon, lithium metal, and silicon), the active materials production may be modelled as the active material precursors production and not as mandatory company-specific process.

Since not all of the mandatory company-specific processes are run by the CFB declarant, the CFB declarant's suppliers have different options to communicate company-specific data:

- Option 1: The suppliers provide to the CFB declarant all activity data, elementary flows, and all the information required for the CFB supporting study and for verification[22].
- Option 2: The suppliers provide to the CFB-declarant a CFB-compliant company-specific dataset[23]. In this case, the CFB-declarant shall make sure that the notified body receives all the document when the CFB-declarant submits the carbon footprint declaration.
- Option 3: The suppliers provide all activity data, elementary flows, and all the information required for the CFB supporting study and for verification to a third-party subject (e.g., a data management company) that combines the inputs from different companies and provides the CFB-declarant with aggregated CFB-compliant datasets for different processes, thus ensuring confidentiality across the supply-chain. In this case, the CFB-declarant, the suppliers, and the third-party subject shall ensure that the notified body receives all the documentation needed for the verification of the carbon footprint declaration.

NOTE: the availability of company-specific data is ensured by the article 38a of the Battery Regulation Proposal that states that "The 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".

6.2 Non-mandatory company-specific processes

Non-mandatory processes are divided into most relevant and non-most relevant processes depending on their relevance on the overall CFB calculation.

The most relevant processes are the following:

- Production of cathode active material precursors: cobalt, nickel, iron and lithium (metallic or as salts).
- Production of anode active material precursors: graphite, lithium metal, hard carbons, silicon.
- Production of electrolyte salt and precursors: $LiPF_6$, lithium salts.

[21] Modelling requirements for company-specific data are described in section 6.4.
[22] Documentation requirements are provided in Section 8.2
[23] Information on the CFB-compliant company-specific datasets is presented in section 6.3. CFB-compliant datasets may be both LCI dataset or LCIA dataset.

— Production of copper, e.g., in the current collectors, busbars and cables.

— Production of aluminium, e.g., in the current collectors, busbars / cables and housing.

— Production of steel, e.g., in the housing.

NOTE: the most relevant processes have been identified based on the results from the Battery PEFCR and literature (e.g., studies from the Global Battery Alliance - GBA[24]). Examples of non-most relevant processes are the production of the solvent used in cathode and anode, of the carbon fibers used in the housing, of the PWB, the manufacturing of the plastic for the collector or housing, etc.

6.2.1 Modelling requirements of the most relevant processes

Two cases are possible for the modelling of the most relevant processes.

Case 1: At least one technologically representative secondary dataset[25] is available in the 'CFB node'[26]. In this case, there are two modelling options:

— Option a): Select the most representative secondary dataset[27]. The electricity in the '–1 level'[28] may be changed with the average consumption mix (modelled as in section 7.1.5) of the country where the process is occurring. In this case, the declarant shall duly justify this modelling in the CFB supporting study. Supplier-specific electricity mix (such as the use of a Guarantee of Origin) shall not be used in this case.

— Option b) A CFB-compliant company-specific dataset (either as LCI or LCIA dataset) referring to the intermediate product with a DQR[29] ≤ 2 may be used.

Case 2: No technologically representative secondary dataset is available in the CFB node. In this case, there are two modelling options:

— Option a): Select a secondary dataset respecting the following hierarchy:

1. Select the most representative EF-compliant dataset available in the LCDN.
2. Select the most representative EF-compliant dataset from any other source.
3. Select the most representative ILCD entry-level compliant dataset either from the LCDN or from any other source.

— Option b) A CFB-compliant company-specific dataset (either as LCI or LCIA dataset) referring to the intermediate product with a DQR ≤ 3 may be used.

The modelling approach used for each most relevant process (i.e., the use of a secondary dataset or of a CFB-compliant company-specific dataset) shall be reported in the CFB supporting study, clearly indicating the modelled process, and any relevant modelling assumption and justification (e.g., choice of a proxy).

6.2.2 Modelling requirements for the non-most relevant processes

Two cases are possible for the modelling of the non-most relevant processes:

Case 1: At least one technologically representative secondary dataset is available in the CFB node. In this case select the most representative secondary dataset.

Case 2: No technologically representative secondary dataset is available in the CFB node. In this case, a secondary dataset shall be selected respecting the following hierarchy:

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[24] The Global Battery Alliance ("GBA"), Greenhouse Gas Rulebook, Generic Rules - Version 1.3, 2022. Available at https://www.globalbattery.org/media/gba-rulebook-master.pdf

[25] A dataset is considered technologically representative if the Technological Representativeness (section 6.3.4) is ≤ 4.

[26] Node dedicated to the CFB in the Life-cycle Data Network (LCDN) available at https://eplca.jrc.ec.europa.eu/LCDN/.

[27] The most representative secondary dataset is defined in this document as the dataset having the highest Technological Representativeness (TeR) according to section 6.5. If there are several datasets with the same TeR, the one with the highest Geographical Representativeness (GeR) according to section 6.5 shall be selected. In the absence of information on the geographical provenience of the material, the global average shall be used.

[28] The electricity dataset(s) connected to the core process one level down the supply chain in the partially disaggregated dataset at '-1 level'.

[29] More information on how to calculate the DQR of a CFB-compliant company-specific dataset is illustrated in section 6.5.

1. Select the most representative EF-compliant dataset available from the LCDN.
2. Select the most representative EF-compliant dataset from any other source
3. Select the most representative ILCD entry-level compliant dataset either from the LCDN or from any other source.

NOTE: Company-specific datasets cannot be used to model a non-most relevant process.

All the secondary datasets used to model each of the non-most relevant process shall be reported in the CFB supporting study.

6.3 CFB-compliant company-specific datasets

A dataset is a document (or file) with life-cycle information of a specified product or other reference (e.g., process), covering its descriptive metadata and either its quantitative life-cycle inventory (in case of a LCI dataset) or life-cycle impact assessment results (i.e., its carbon footprint, in case of an LCIA dataset).

A company-specific dataset is a dataset describing a company-specific process, where all the activity data are company-specific, and shall refer to a specific battery model produced in a specific production plant.

A CFB-compliant company-specific dataset is a dataset that respects the following requirements:

- The modelling is done according to rules set in the present document.
- The nomenclature of the elementary flows is aligned with the EF3.1 reference package available on the EF developer's page[30].
- For the process datasets and product flow, the nomenclature shall be compliant with the 'ILCD Handbook – Nomenclature and other conventions[31].
- The DQR is calculated as described in section 6.5.
- The meta-data information consists of:
    - The confidential information (i.e., accessible only to the notified body) described in Section 8.2.2 and in the section 5 of the EF Data Guide v2[32] that shall be available to the notified body.
    - The information described in Section 8.2.3 that shall be communicated to the user of such dataset for a correct use of the dataset.
- In case a CFB-compliant company-specific dataset refers to an intermediate product, the system boundaries shall not include the 'Distribution' and the 'End-of-life' life-cycle stage.
- It shall be externally verified.

The CFB declarant shall make sure that the notified body receives all the documentation of all the CFB-compliant company-specific datasets used in the CFB at the same time so to verify them as well.

In the case of a CFB-compliant LCI dataset, the dataset shall include the LCI results and the LCIA results of the climate change impact category (section 5) expressed in kg CO_2 eq. In the case of a CFB-compliant LCIA dataset, the dataset shall include the LCIA results of the climate change impact category (section 5) in kg CO_2 eq.

6.4 Requirements for the collection of company-specific data

The company-specific data shall refer to a specific battery model produced in a specific manufacturing plant.

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30 EC, Developer Environmental Footprint (EF), 2023. Available at https://eplca.jrc.ec.europa.eu/LCDN/developerEF.xhtml.

31 European Commission - Joint Research Centre - Institute for Environment and Sustainability: International Reference Life-cycle Data System (ILCD) Handbook - Nomenclature and other conventions. First edition 2010. EUR 24384 EN. Luxembourg. Publications Office of the European Union; 2010. Available at https://eplca.jrc.ec.europa.eu/uploads/MANPROJ-PR-ILCD-Handbook-Nomenclature-and-other-conventions-first-edition-ISBN-fin-v1.0-E.pdf.

32 Simone Fazio, Luca Zampori, An De Schryver, Oliver Kusche, Lionel Thellier, Edward Diaconu. Guide for EF compliant data sets: Version 2.0, EUR 30175 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-17951-1, doi:10.2760/537292, JRC120340. Available at https://eplca.jrc.ec.europa.eu/permalink/Guide_EF_DATA.pdf

The company-specific data to be collected for the creation of company-specific datasets shall include all known inputs and outputs for the processes, including:

- Examples of inputs:
  - Material inputs that end up in the product (e.g., minerals or metals, semi-finished materials, chemical feedstocks etc).
  - Energy that is consumed directly and indirectly in the processing plant (e.g., electricity, steam, thermal energy required by the process, but also energy and fuels required for auxiliary activities such as transport or forklift within the plant premises).
  - Auxiliaries, (e.g., chemicals, cleaning material, lubricants, refrigerants).
  - Transport distances and means of transport
  - Land and water.
- Examples of outputs:
  - Any material output, including wastewater
  - Any elementary flow, (e.g., substances directly released to the environment by the corresponding process without further treatment), such as direct emissions of GHG from, for example, the oxidation of carbonaceous material during smelting or calcination or from fuel combustion. Emissions that are additional to the corresponding energy process (i.e., not accounted for within the corresponding dataset) and that are not monitored via measurements shall be estimated based on stoichiometric calculations.

Specific requirements are set in case of the inputs and outputs of continuous or semi-continuous processes, as following:

- Measurements shall be collected at the points of consumption or emission directly relative to the process considered for the battery in the scope.
- If some of these data are not available (for example, the battery process is run in the same plant with multiple other processes) then a calculation for an allocation of the flows is allowed according to section 7.2.1. Appropriate justification and documentation shall be provided in the CFB supporting study in this case.

The company-specific data shall not be modelled using secondary data from literature. As the carbon footprint declaration shall be specific to a battery model produced in a defined production site, sampling of data collected from different plants producing the same battery model is not be allowed according to Annex II (5) of the Battery Regulation Proposal.

Company-specific data collection shall be done on an annual basis (either the most recent calendar year or fiscal year) and be provided as a yearly average. If the product for which the carbon footprint applies is produced for less than 12 months, the data shall be collected for the time period in which the product is manufactured or from the beginning of the year until the stop of production. In exceptional cases, data collection may refer to shorter (or different) periods of time. In these cases, the reason for this exception shall be properly justified in the CFB supporting study.

Company-specific emission data may be based on direct measurements or be calculated using company-specific activity data and related emission factors (e.g., litre of fuel consumption and emission factors for combustion in a vehicle or boiler). Whenever the sector of the product in scope is covered by EU ETS monitoring rules, the user of the CFB rules should follow quantification requirements as set out in Regulation (EU) 2018/2066 for the processes and GHGs covered therein. The data may need scaling, aggregation or other forms of mathematical treatment to bring them in line with the functional unit and reference flow of the process. Typical specific sources of company-specific data are: (a) process- or plant-level consumption data; (b) bills and stock/inventory changes of consumables; (c) emission measurements (amounts and concentrations of emissions from flue gas and wastewater); (d) composition of products and waste; (e) procurement and sale department(s)/unit(s). All data sources and mathematical treatment applied to the data shall be provided in the CFB supporting study.

A company quality system (i.e., ISO 9001 or equivalent) shall be in place in order to demonstrate that all the activity data have been correctly collected and managed, and these are representative of a yearly average of the manufacturing of the battery in the scope.

Annex 1 and Annex 2 presents the data collection requirements in the “Raw materials acquisition and pre-processing" and in the “Manufacturing” life-cycle stages, respectively.

6.5 Data quality rating (DQR) of the CFB declaration and of CFB-compliant datasets

A Data Quality Rating (DQR) shall be calculated for the declared value of the CFB. To calculate the DQR, the following procedure applies:

1. Evaluate the 3 DQR criteria, Technological Representativeness[33] (TeR), Geographical Representativeness[34] (GeR), Time-related Representativeness[35] (TiR) for all the background datasets (both company-specific and secondary). The values of each criterion shall be assigned based on Table 1.
2. Calculate the absolute value of the carbon footprint of each process by multiplying the absolute carbon footprint of the dataset by the corresponding activity data

NOTE: If a process consumes 3 kWh of electricity and the carbon footprint of the dataset modelling the electricity consumption is equal to 0.6 kg CO_2eq / kWh, then 0.6 kg CO_2eq / kWh shall be multiplied by the corresponding activity data (3 kWh in this case) to obtain the absolute value of the carbon footprint of the process).

3. Calculate the carbon footprint contribution (in %) of each process. The carbon footprint contribution is the ratio between the absolute carbon footprint of the process divided by the sum of the absolute values. The absolute values are used to always have positive contributions. The sum of the absolute values is equal to the CFB in case there is no process having a negative carbon footprint.
4. Calculate the value of each DQR criteria of the declared value of the CFB declaration as a weighted average, e.g., the TeR of the CFB declaration/dataset is the weighted average of the TeR of the single datasets weighted with their absolute carbon footprint contribution.
5. Calculate the DQR score of the declared value of the CFB as: (TeR + TiR + GeR)/3

This procedure shall be used to calculate also the DQR of CFB-compliant dataset(s) used to calculate the CFB.

The total DQR and the values of the single DQR criteria (TeR, GeR, and TiR) of the CFB declaration shall be provided in the public version of the CFB supporting study. The total DQR score and the single DQR criteria of the CFB-compliant dataset shall be provided to the user of these datasets.

Table 1. How to assign the values to DQR criteria to company-specific and secondary datasets (TeR, GeR, TiR). TeR: Technological Representativeness. GeR: Geographical Representativeness. TiR: time-related Representativeness.

Quality rating	**$TiR_{dataset}$**	**$TeR_{dataset}$**	**$GeR_{datasets}$**
1	The "reference year" of the dataset/CFB falls within the time validity of the secondary dataset	The modelled technology is exactly the same as the one in scope of the dataset/CFB.	The modelled process takes place in the country for which the dataset/CFB is valid.
2	The "reference year" of the dataset/CFB dataset is maximum 2 years beyond the time validity of the secondary dataset	The modelled technologies are included in the mix of technologies in scope of the dataset/CFB.	The modelled process takes place in the geographical region (e.g., Europe, Asia, North America, Africa) for which the dataset/CFB is valid.

[33] The term '“technological representativeness’ used in relation to this procedure method is equivalent to “technological coverage” used in EN ISO 14044:2006.

[34] The term '“geographical representativeness” used in relation to this procedure method is equivalent to “geographical coverage” used in EN ISO 14044:2006.

[35] The term “time-related representativeness” used in relation to this procedure method is equivalent to “time-related coverage” used in EN ISO 14044:2006.

3	The "reference year" of the dataset/CFB is maximum 3 years beyond the time validity of the secondary dataset.	The modelled technologies are only partly included in the scope of the dataset/CFB.	The modelled process takes place in one of the geographical regions for which the dataset/CFB is valid, or the dataset covers several regions (e.g., global - GLO).
4	The "reference year" of the dataset/CFB is maximum 4 years beyond the time validity of the secondary dataset.	The modelled technologies are similar (i..e, technological proxy) to those included in the scope of the dataset/CFB.	The modelled process takes place in a country that is not included in the geographical region(s) for which the dataset/CFB is valid, but it is estimated that there are sufficient similarities based on expert judgement.
5	The "reference year" of the dataset/CFB is more than 4 years beyond the time validity of the secondary dataset.	The modelled technologies are different from those included in the scope of the dataset/CFB.	The modelled process takes place in a different country than the one for which the dataset/CFB is valid.

Source: JRC analysis.

If the electricity is changed in the '–1 level' of one of the most relevant processes (as allowed in section 6.2.1), the GeR of the dataset shall be calculated as follows:

$$GeR_{new} = GeR_{old} - \left(GeR_{old} - GeR_{new,-1}\right) * Contribution_{old,-1}$$

, where:

- GeR_{new} is the GeR of the secondary dataset after changing the dataset describing the electricity consumption in the –1 level, based on Table 1.
- GeR_{old} is the GeR of the secondary dataset before changing the dataset describing the electricity consumption in the –1 level, based on Table 1.
- $GeR_{new,-1}$ is the GeR of the dataset describing the electricity consumption in the '-1 level' after the adjustment based on Table 1. $GeR_{new,-1}$ represents the geographical representativeness of the electricity production referring to where the process happens in reality.
- $Contribution_{old,-1}$ is the contribution, as a %, of the impacts of the electricity consumption in the '-1 level' compared to the total carbon footprint of the secondary dataset.

*NOTE: Here is an illustrative example of how the GeR is adjusted if the electricity in the '–1 level' is changed to model a most relevant process in a company-specific dataset. The dataset is assumed to be the global production of a material, having a GeR_{old} of 3 (see Table 1). The GeR of the adjusted '-1 level' process (i.e., $GeR_{new,-1}$) is assumed to be 1 as the electricity of the '-1 level' has been adjusted with the effective country-specific electricity consumption mix of the is country where the process occurs (see Table 1). The contribution of the electricity (i.e., $Contribution_{old,-1}$) to the total carbon footprint of this secondary dataset is 33% . This means that the GeR of the secondary dataset after the electricity adjustment (i.e., GeRnew) will be equal to: 3-(3-1)*33%=2.33.*

NOTE: This approach leads to a weighted adjustment taking into account the contribution of the '-1 level' adjusted datasets to the overall carbon footprint of the dataset. If e.g., the electricity contributes 100% to the total carbon footprint of the dataset, adjusting it to GeR=1 will lift the secondary dataset to a GeR of 1. If the contribution of the electricity to the overall carbon footprint of the secondary datasetwould be negligible, also the impact of its –1 level adjustment to the GeR will be negligible.

7 Inventory data – Modelling requirements

7.1 Electricity modelling

7.1.1 General guidelines

The following electricity modelling shall be used, in hierarchical order:

1. On-site generated electricity modelled according to section 7.1.2 if it meets the conditions set in the same section.
2. Supplier-specific electricity product modelled according to section 7.1.3 if the contractual instrument meets the set of minimum criteria described in sections 7.1.3.1 to 7.1.3.5.
3. Residual consumption mix modelled according to section 7.1.4 if the activity occurs in a country where it is possible to claim a supplier-specific electricity product described in point (2) of the hierarchy. The residual consumption mix shall be used also if the CFB declarant itself did not claim any supplier-specific electricity product. The residual consumption mix characterizes the unclaimed, untracked or publicly shared electricity and prevents double counting with the use of supplier-specific electricity product in the point (2) of the hierarchy.
4. Average consumption mix modelled according to section 7.1.5 if the activity occurs in a country where it is not possible to claim the supplier-specific electricity product described in point (2) of the hierarchy (i.e., no residual consumption mix is available). The average consumption mix reflects the total electricity mix including claimed or tracked electricity.

The use of carbon intensity factors values provided by a grid operator or certificate-issuing entity is not permitted.

NOTE: certificates for the contractual instruments could include an estimation of the carbon footprint of the electricity delivered. However, there is no guarantee that such data are CFB-compliant or following a common, uniform standard and for this reason they are not allowed for the calculation of the CFB.

The way the electricity is modelled in the CFB shall be reported in the CFB supporting study.

7.1.2 On-site generated electricity

The on-site generated electricity shall be claimed if the electricity is supplied to the plant from a production asset within the premises of the energy-consuming plant and if the production asset is connected to the energy-using plant by means of a direct and dedicated connection.

If the energy-consuming plant is also connected to the electricity grid and electricity is sourced from the grid in addition to on-site generation (e.g., during times of low on-site generation), all energy sourced from the grid shall be accounted and modelled following the points (2), (3), or (4) of the hierarchy described in section 7.1.1. The maximum amount of electricity that may be claimed in a year is the difference between the yearly total amount of energy produced and the yearly amount of energy injected in the grid. The CFB declarant shall provide evidences in the CFB supporting study of the values of on-site generated electricity considered in the CFB calculation i.

If contractual instruments of any type, related to the on-site generated electricity, have been sold to a third party, then the on-site generated electricity cannot be claimed in the CFB. If such electricity is consumed in the plant, then it shall be modelled following the points (2), (3) or (4) of the hierarchy described in section 7.1.1.

No credit shall be modelled if the amount of electricity produced exceeds the amount consumed on-site within the defined system boundary and it is sold to, e.g., the electricity grid.

The processes that model the electricity production per energy type and country/region (e.g., production of 1 MWh solar energy in the corresponding country/region) shall be modelled as a “non-most relevant processes” (section 6.2.2), where datasets describing medium-voltage may be used for low-voltage, neglecting the conversion losses.

7.1.3 Supplier-specific electricity product

The environmental integrity of the use of supplier-specific electricity products depends on ensuring that the related contractual instruments (for tracking) are reliable and unique. Without this, the CFB lacks the accuracy and consistency needed to drive claims on the electricity procurement. Therefore, the contractual instrument shall be claimed in the CFB if the respect of the following five minimum criteria (sections 7.1.3.1 to 7.1.3.5) is proved in the CFB supporting study.

The processes that model the electricity production per energy type/source and country/region (e.g., production of 1 MWh solar energy in the corresponding country/region) shall be modelled as a "non-most relevant processes" (section 6.2.2), where datasets describing medium-voltage may be used for low-voltage, neglecting the conversion losses.

NOTE: *the Guarantees of Origin (GO) are currently the only contractual instruments that comply with the minimum reliability criteria in the European Union. Evidences are currently missing of other extra- European instruments that meet the criteria below. Once evidences will be provided for other extra European instruments, these will be verified by the notified bodies and residual consumption mix will have to be considered for the countries where this instrument is in place.*

7.1.3.1 Criterion 1 – Convey attributes

To satisfy the criterion, the contractual instrument shall:

- Convey the energy source mix and complementary attributes of the product associated with the unit of electricity produced.
- Include an explanation of the calculation method used to determine the energy source mix of the product.

7.1.3.2 Criterion 2 – Be a unique claim

To satisfy the criterion, the contractual instrument shall:

- Have mechanisms in place that ensure it is the only instrument that carries the environmental attribute claim associated with that quantity of electricity generated.

NOTE: an example of mechanism is to be externally-verified and audited.

- Have mechanisms in place to ensure the instrument can be claimed only once.
- Be tracked and redeemed, retired, or cancelled by or on behalf of the company (e.g., by an audit of contracts, third party certification), or handled automatically through other disclosure registries, systems, or mechanisms.
- Be associated with a quantity of generated electricity that is reported and considered for the determination of the country-specific residual consumption mix, and this unique residual consumption mix is disclosed publicly by a competent authority. Sometimes national laws and regulations may define a residual consumption mix for a geographical area that is different from the country. The CFB declarant shall report the residual consumption mix and its source in the CFB supporting study.

NOTE: If different tracking systems coexist in one country, only one residual consumption mix needs to be published for the country (or for part of the country), taking into account all the contractual instruments that have been issued in the country for the considered period.

NOTE: In the GoO instrument, States that adhere to this instrument are responsible of publishing the country residual consumption mix..

- Allow for the unambiguous identification of the technology type[36], age and location and capacity of the energy generation facility to which it refers.
- Refer to an energy generation facility that is located in a country with a tracking system in place that meets the minimum criteria for tracking systems specified in section 7.1.3.3.

[36] The Technology Type (of a Production Device) is the "type of technology used by the Production Device in generating Output from Input" (EN16325 GO standard).

7.1.3.3 Criterion 3 – Be issued from a tracking system that fulfils specific criteria

To satisfy the criterion, the contractual instrument shall be issued by a tracking system that fulfils the following criteria:

- Is based on objective, non-discriminatory, and transparent criteria for the issuing certificates.
- Is a unique entity per geographical area and per type of energy production and it shall be governmentally appointed.
- Relies on accurate, reliable, and fraud-resistant mechanisms for the issuance, transfer and cancellation of certificates.
- Is independent from the verifier.
- Entrusts the issuance of certificates, as well as the supervision of their transfer and cancellation of certificates, to a legal entity or entities who are independent from the production, trade of energy, and the corresponding certificates.
- Whose activities are governed by transparent rules and procedures.
- Whose decisions may be challenged and reviewed in the context of proceedings before an independent judiciary.
- Whose use is enforceable by national legislation for claims on the origin of consumed energy.
- Works in interaction with the authority publishing the residual consumption mix in a way that prevents double claims of renewable energy sources and other environmental attributes.

NOTE: An example for a country-specific issuing body is the Association of Issuing Bodies37 i.e., the organisation which governs the European Energy Certificate System.

NOTE: In some cases, the tracking systems can have different geographical boundaries than a country.

7.1.3.4 Criterion 4 – Be as close as possible to the period to which the contractual instrument is applied

To satisfy the criterion, the contractual instrument shall:

- Ensure that certificates are valid no longer than 12 months after the represented electricity was generated. This means that the certificate shall be used (hence cancelled/redeemed/retired) within 18 months after the electricity was generated.

NOTE: Each Guarantee of Origin within the European Energy Certificate System (EECS) shall be valid for twelve months after the production of the relevant energy unit. States member of the GoO instrument ensure that all guarantees of origin, which have not been cancelled, will expire at the latest 18 months after the production of the energy unit. Expired guarantees of origin are includedin the calculation of the residual energy mixes.

7.1.3.5 Criterion 5 - Be sourced from the same market in which the reporting entity's electricity-consuming operations are located and to which the instrument is applied

The electricity to which the contractual instruments refer to and the company claiming the contractual instrument shall be within the same market boundaries.

The "market boundary" refers to an area in which:

- There is a physical interconnection between the point of generation and the point of consumption of renewable electricity. When interconnection happens across different grids, there shall be an entity that coordinates and tracks the exchange between such grids.
- The countries' utilities/energy suppliers recognize each other's energy source tracking instruments and have a system in place to prevent double counting of claims

[37] Association of issuing bodies, 2023. Available at http://www.aib-net.org.

NOTE: the definition of market is based on CDP Scope 2 Technical Guidance: Accounting of Scope 2 emissions; Chapter 2.3 - "Claiming renewable electricity use: the market boundary criteria" that can be downloaded from https://www.irecstandard.org/credibility/.

7.1.4 How to model the residual consumption mix'

If a secondary dataset modelling the residual consumption mix in a specific country (e.g., residual consumption mix in Estonia) is registered in the node dedicated to the CFB in the LCDN, then this dataset shall be used. Otherwise, the CFB declarant shall model its own residual consumption mix for the considered country using the following approach:

1. Use the composition of the residual consumption mix (e.g., X% of MWh produced with hydro energy, Y% of MWh produced with coal power plant). The most recent composition shall be used.
2. The background processes per energy type and country/region (e.g., production of 1MWh solar energy in the corresponding country/region) shall be modelled as a "non-most relevant processes" (section 6.2.2).

If the residual consumption mix is modelled with own data, the source, the year, the geographical boundaries, the percentage from each electricity source, and the background datasets shall be provided in the CFB supporting study.

7.1.5 How to model the average consumption mix

The average consumption mix shall be modelled as a "non-most relevant processes" (section 6.2.2), i.e., the average consumption mix shall be modelled with a secondary dataset. If the node dedicated to the CFB in the LCDN includes a dataset modelling the average consumption mix in the country, or in the region (EU) of interest, that dataset shall be used giving priority first to the country, and then to the region. Otherwise, the global electricity consumption mix registered in the node dedicated to the CFB in the LCDN shall be used.

7.1.6 A single location with more than one electricity mix

If the consumed electricity comes from more than one electricity source (e.g., on-site electricity generation, supplier-specific electricity, or unspecified electricity purchased from the grid), each mix source shall be used in terms of its proportion to the total kWh of electricity consumed. For example, if a fraction of the total kWh consumed comes from a specific supplier, a supplier-specific electricity product shall be used for this amount (section 7.1.2).

7.2 Allocation rules

If a process or facility provides more than one function, i.e., it delivers several goods and/or services ('coproducts'), it is 'multifunctional'. In these situations, all inputs and emissions linked to the process shall be partitioned between the product of interest and the other co-products in a principled manner. Systems involving multi-functionality of processes shall be modelled in line with the decision hierarchy as in EF method (Recommendations 2279/2021 - Annex I – section 4.5). This implies the following hierarchy (deviating specific requirements are detailed in the following):

1. Subdivision
2. Allocation based on a relevant underlying physical relationship (mass or energy)
3. Economic allocation.

Economic allocation shall be applied when the price difference between the different outputs is higher than a factor of four. Sixty months global price (or revenues, or costs) averages shall be used as minimum to assess price differences. All allocation factors, the approach for calculating them and the underlying data sources shall be disclosed in the CFB supporting study. If the process has been operative for shorter time, a shorter timespan (min 1 year) may be used if duly justified in the CFB supporting study. In this case, the CFB shall be updated at the latest when 5 year average values are available.

NOTE: a typical example where economic allocation applies is where high value metals (such as platinum group metals like iridium, osmium, palladium, platinum, rhodium, ruthenium or other precious metals e.g., gold and silver) are produced together with base metals or other low value fractions.

7.2.1 Allocation of energy and auxiliary inputs of production lines

If company-specific data is collected for energy auxiliary inputs or other consumables and subdivision is not representative for the considered process, allocation of the corresponding inputs may be done. This applies if only one meter (e.g., for electricity) is available for several production lines of a plant or if a process step (e.g., dry room) processes products from different production lines.

The following hierarchy shall be used:

1. Allocation by mass (or other physical properties) that most closely represent the drivers for the corresponding input
2. Allocation using the installed capacity (or another appropriate criterio).

This approach may only be used if the production steps, production equipment, and the products themselves are similar, (e.g., battery cells with the same geometry, but different properties). The chosen method shall be reported and documented in the CFB supporting study, including the reasoning why the approach was taken. In all cases, the sum of the allocation shall equal the total energy consumption (measured).

7.2.2 Allocation and modelling of the battery housing in EV batteries

The housing of the EV battery delivers the following functions to the battery: A) holding the cells or modules; B) integrating the battery cooling system and / or insulation.

In case of battery housing providing additional functions to the electric vehicle (e.g., torsional stiffness, crash resistance, etc) beyond the two main functions A) and B) above, then the modelling of the battery housing may be done as following (in hierarchical order) if corresponding justification is provided in the CFB supporting study:

1. Physical partitioning: the components of the housing that provide one or more functions to the electric vehicle (and not contributing to functions A) and B) above) shall be excluded from the system boundary.
2. Virtual housing approach: when physical partitioning is not feasible, a virtual housing shall be modelled (i.e., the size of the housing shall be re-calculated according to the size of the battery and a reference thickness for each material). The virtual housing shall be modelled as:
   (a) The size of the housing will be re-calculated according to the size of the battery. Based on the actual Length (**L**), the Width (**W**) and the Hight (**H**) of the battery housing, the Area of the virtual housing shall be calculated as:

   $$Area=(L \cdot W) \cdot 2+(W \cdot H) \cdot 2+(L \cdot H) \cdot 2$$

   (b) The materials to model the virtual housing shall be the same as used in the real housing. In addition:
      i. If only one material is used in the real housing, the virtual housing shall be considered as made of such material.
      ii. If more than one material is used in the real housing, only those materials accounting for at least 95% of the weight of the real housing shall be considered. Those materials shall be selected in decreasing order of importance, from the material contributing most to the material contributing the least in terms of weight, until the minimum threshold of 95% is reached. Once the materials are selected, the mass of the different materials shall be normalized to 100%.

   (c) The “Weight” of each material in the virtual housing shall be calculated as:

   $$Weight_{mat\_i}=Area \cdot \text{Percentage}_{mati} \cdot t_{mat\ i} \cdot \rho_{mat\ i}$$

Where:

— Area: total area of the virtual housing, as calculated in point (a) above

— Percentage$_{mati}$: proportion of material *i*, as calculated in point (b)

— t_{mati}: reference thickness of material *i*

— $\rho mati$: density of material *i*

The following reference thickness values for different materials shall be considered: aluminium (2.5 mm); steel (1.75 mm); carbon fibers based material (2.02 mm). The declarant may prove that different thickness would be more appropriate for the considered battery housing for other materials (e.g., when other innovative materials are used).

The implementation of the virtual housing approach shall be reported in detail in the CFB supporting study, including all assumptions used, with details of the model and experimental values used especially in the case of deviating from the reference thickness values above.

A battery housing is considered to provide additional functions if it contributes to the torsional stiffness and the crash resistance. In the context of the CFB and for the sake of verification, the sole torsional stiffness shall be considered to identify whether the battery housing provides additional functions or not. For this purpose, the CFB applicant shall report two values of torsional stiffness of the vehicle in the CFB supporting study: i) with battery housingand ii) without battery housing. If the torsional stiffness with battery housing is higher than the stiffness without battery housing then the battery housing is contributing to the stiffness of the vehicle and thus it can be considered as providing additional functions to the vehicle.

7.3 Recycling content and end-of-life modelling

The recycled content and the waste generated during all the life-cycle stages shall be modelled with the use of the Circular Footprint Formula (CFF) and shall be reported at the life-cycle stage where the waste management occurs.

The CFF shall not be used for any waste (i.e., materials or objects rejected during the battery manufacturing process) that is re-used as an integral part in the same process and that does need to be recycled (e.g., run-around scrap) since this is not considered manufacturing waste according to the Article 2 of the Battery Regulation Proposal. However, emissions and process inputs associated with their processing shall be accounted for in the corresponding life-cycle stage.

The default recycled content of the materials in the battery scope shall be 0 unless evidence of the traceability throughout the supply-chain is provided in the CFB supporting study. The 'End-of-life' life-cycle stage of the main product (i.e., the battery for which the CFB is developed and declared) shall be modelled according to Figure 3 using the default collection rate according to Section 7.3.1 and the default battery cell recycling process as provided in Annex III. A company-specific collection rate may be used only for the share of batteries covered by an ownership business models where the property of the battery stays with the manufacturer and higher collection rates may be proved. A company-specific battery cell recycling process may be used only for the share of the batteries the CFB declarant is able to provide evidence that the batteries will be recycled in a specific recycling plant and that the specific recycling process corresponds to the battery model for which the CFB is declared. The corresponding evidence shall be provided in the CFB supporting study.

Section 7.3.1 describes how to apply the CFF to the recycled content and to the 'End-of-life' life-cycle stage of the battery in scope. For any other case, the section 4.4.8 of the general EF method applies.

7.3.1 The CFF applied to the battery in scope

The below equation describes how to use the CFF to the battery in scope. In particular, it should be noted that:

- The CFF shall be applied per material, unless specified differently in the description of the single parameters.
- For clarity, the "material" part of the CFF has been divided into four terms, related with different processes along the production and end-of-life stage:
    - Impacts of using primary and secondary materials in the battery production, i.e., when the recycled content is different than 0.
    - Impacts of producing secondary materials from the dismantling: steel and aluminium from the housing and copper from the cables.
    - Impacts of producing secondary materials from the PWB recycling after the battery dismantling: copper, gold, and palladium.
    - Impacts of producing secondary materials from the battery cell recycling: copper, nickel sulphate, and cobalt sulphate in the default 'End-of-life' life-cycle stage.

— The default 'End-of-life' life-cycle stage of the battery in scope (illustrated in Figure 3) assumes that only a fraction of the batteries is properly collected and sent to (manual) dismantling. The outputs of the dismantling are the battery cell and components sorted for materials recycling (steel and aluminium from the housing; copper, gold, silver, and palladium from the PWB; copper from the cables). The sorted plastic is sent to energy recovery and the rest to landfill. The dismantled battery cell is then sent to the default battery cell recycling process (illustrated in Figure 3 and detailed in the Annex III) that is composed of a pyrometallurgical and hydrometallurgical treatment (that recycles copper, nickel sulphate, and cobalt sulphate). On the other hand, a remaining fraction of the batteries is assumed to be not properly collected and treated (named as "non-collected" batteries in Figure 3) and assumed to be roughly dismantled (with a process similar to that for properly collected batteries above, but without carrying out the recycling of the PWB), whereas battery cells are assumed to be landfilled. The End-of-life' life-cycle stage of the battery waste (i.e., the battery for which the CFB is developed and declared) shall be modelled using the standard parameters of the CFF as described below, unless specified differently in the description of the single parameters.

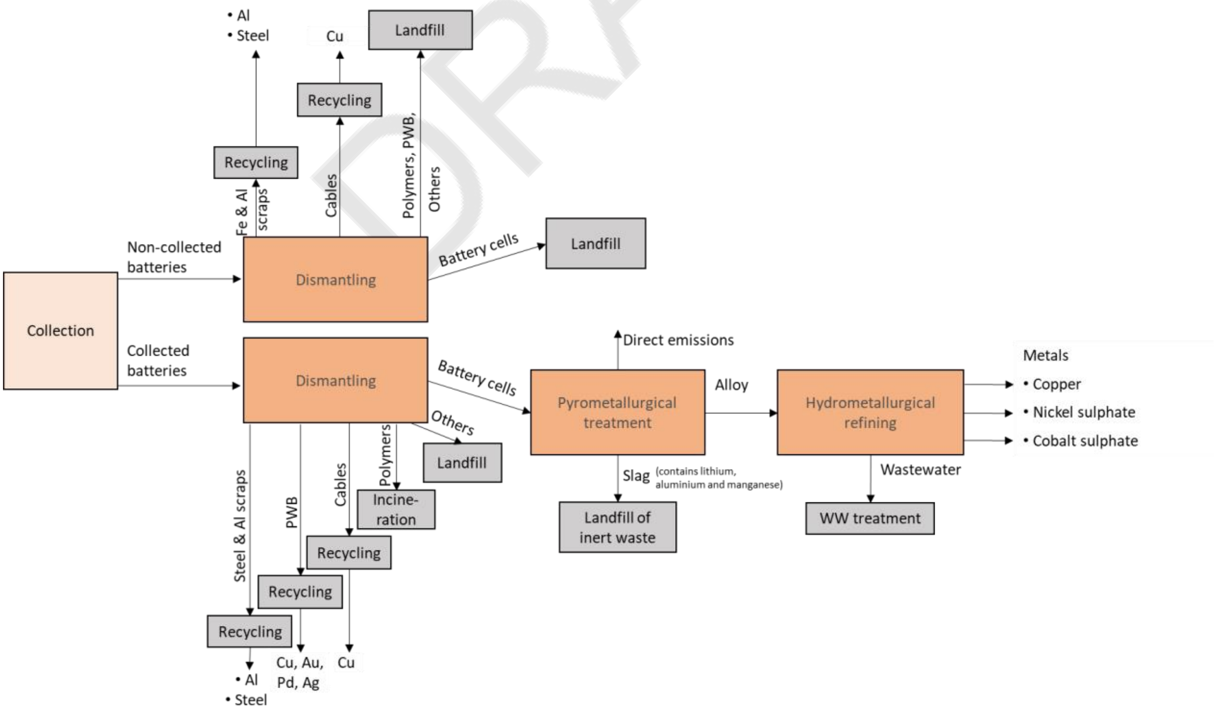
— The impacts of collecting and dismantling the waste batteries shall not be included in the model (i.e., they have defined as cut-off in section 4.1). The collection rate is expressed with the parameters R_{coll} in the equation below, while the efficiency of the dismantling is supposed to be 100%.

— The impacts of the battery cell recycling shall not be allocated per material but shall be allocated to the full battery using an average A per battery. Annex III illustrates the default battery cell recycling.

— The impacts of recycling of the PWB shall not be allocated per material but shall be allocated to the full PWB using an average A per the PWB.

— The incineration with energy recovery only applied to the plastic waste from the dismantling of the properly collected batteries. The energy recovery from plastics in the battery cells is instead accounted by the values of the default battery cell recycling process.

Figure 3. Schematic flowsheet of the default 'End-of-life' life-cycle stage of the battery in scope. PWB: printed wiring board.



Source: JRC

Equations describing how to apply the CFF to the recycled content and to the 'End-of-life' life-cycle stage of the battery in scope are:

— (Material input): Impacts of using primary and secondary materials:

$$\sum_{Mat}[(1-R_{1\_Mat)}\text{x}E_{v\_Mat}+R_{1\_Mat}\text{x}\left(A_{Mat}\text{ x }E_{recycled\_Mat}+(1-A_{Mat})\text{ x }E_{V\_Mat}\text{ x }\frac{Q_{Sin\_Mat}}{Q_{P\_Mat}}\right)]$$

— (Dismantling): Impacts and credits of producing secondary materials from the dismantling (to calculate for steel and aluminium from the housing; copper from the cables):

- Materials from the properly collected fraction of the battery

$$R_{coll}\text{ x }\sum_{Mat}\left[(1-A_{Mat})\text{ x }R_{rec,c\_Mat}\text{ x }\left(E_{recEoL\_Mat}-E^{*}_{V\_Mat}\text{ x }\frac{Q_{Sout\_Mat}}{Q_{P\_Mat}}\right)\right]$$

- Materials from the non-properly collected fraction of the battery

$$+(1-R_{coll})\text{ x }\sum_{Mat}\left[(1-A_{Mat})\text{ x }R_{rec,nc\_Mat}\text{ x }\left(E_{recEoL\_Mat}-E^{*}_{V\_Mat}\text{ x }\frac{Q_{Sout\_Mat}}{Q_{P\_Mat}}\right)\right]$$

— (Electronics recycling) Impacts and credits of producing secondary materials from the PWB recycling after the battery dismantling (to calculate for copper, gold, silver, and palladium):

- PWB from the properly collected fraction of the battery

$$R_{coll}\text{ x }[(1-A_{PWB})\text{ x }E_{recEoL\_PWB}-\sum_{Mat}\left[(1-A_{Mat})\text{ x }\left(R_{rec,c\_Mat}\text{x }E^{*}_{V\_Mat}\text{ x }\frac{Q_{Sout\_Mat}}{Q_{P\_Mat}}\right)\right]$$

— (Cell recycling): Impacts and credits of producing secondary materials from the battery cell recycling (to be calculated for copper, nickel sulphate, and cobalt sulphate in the default End-of-life' life-cycle stage):

$$R_{coll}\text{ x }\left((1-A_{Battery})\text{ x }E_{recEoL\_Battery}\right)$$

$$+R_{coll}\text{ x }\sum_{Mat}\left((1-A_{Mat})\text{ x }R_{rec,c\_Mat}\text{ x }\left(E_{recEoL\_Mat}-E^{*}_{V\_Mat}\text{ x }\frac{Q_{Sout\_Mat}}{Q_{P\_Mat}}\right)\right)$$

— (Energy recovery): Impacts due to energy recovery of the dismantled plastic:

$$R_{coll}\text{ x }\sum_{Mat}[(1-B)\text{ x }R_{3,c\_Mat}\text{ x }(E_{ER_{Mat}})]$$

— (Disposal): Impacts of disposal:

- PWB, polymers, battery cell, and other materials not-being recycled from the dismantling of the non-properly collected battery waste

$$(1-R_{coll})\text{ x }\sum_{Mat}(1-R_{rec,nc\_Mat}\text{ x }E_{D_{Mat}})$$

- Other materials not-being recycled from the dismantling of the properly collected battery waste

$$R_{coll}\text{ x }\sum_{Mat}(1-R_{rec,c\_Mat}\text{ x }E_{D_{Mat}})$$

All the above equations shall be summed to obtain the final result.

The parameters of the CFF to be applied to the battery recycled content and to the battery End-of-life' life-cycle stage[38] are:

— A_{Mat}: Material-specific allocation factor of burdens and credits between two life-cycles (i.e. the one supplying and the one using recycled material) aiming to reflect market realities. Values of parameter "A_{Mat}" shall be selected according to Table 2. In case a material is not present in Table 2, reference application-specific values shall be used (as available in the Part C of the Annex II of the EF method[39]). If no values for a specific application are not available , material-specific values for the parameter "A_{Mat}" may be used (using same reference as in above). If values of parameter "A_{Mat}" for the considered materials are not available, the default value of 0.5 shall be used.

[38] If the CFF is to be applied to model the waste treatment in other life-cycle stage, the CFF and the CFF parameters as described in the section 4.4.8 of the general EF method apply.

[39] Available at https://eplca.jrc.ec.europa.eu/permalink/Annex_C_V2.1_May2020.xlsx.

— $A_{Battery}$: Battery-specific allocation factor. It shall be equal to 0.2.

— A_{PWB}: PWB-specific allocation factor. It shall be equal to 0.2.

— B: allocation factor of energy recovery processes. It shall be equal to 0.

— R_{1_Mat}: Material-specific recycled content, i.e., the proportion of material in the input to the production that has been recycled from a previous system. R_1 is by default equal to 0 for all the materials, unless a different value may be duly proved. When using a company-specific R_1 values other than 0, traceability throughout the supply-chain is necessary, and evidence shall be provided in the CFB supporting study for verification. The documentation required to demonstrate the minimum recycled content according to the Article 8 of the Battery Regulation Proposal are considered evidence also for an R1 different than 0. Material-specific values based on supply market statistics shall not be accepted as a proxy for R_1.

— R_{coll}: Battery collection rate (i.e. rate of the de-registered vehicles that are properly collected to be dismanteled and recycled). The default R_{coll} is 0.7. Different company-specific values may only be used for the share of batteries covered by an ownership business models where the property of the battery stays with the manufacturer and higher collection rates may be proved. Evidence of such ownership models shall be provided in the CFB supporting study.

NOTE: the Impact assessment in the ELV Regulation states that around 32% of the de-registered vehicles are of unknown whereabouts (so-called "missing vehicles")[40]. Similar numbers have been confirmed by a recent JRC report[41]. Since this value is for all the vehicles and not only for electric vehicles, a slightly higher collection rate (i.e., 70% instead of 68%) has been assumed.

— R_{rec,c_Mat} and R_{rec,nc_Mat}: Material-specific recycling yield, i.e., the proportion of the material in the product that will be recycled in a subsequent system taking into consideration only the recycling yield. It does not include collection rate and dismantling efficiency. Two different values are used, R_{rec,c_Mat} for the properly collected fraction of batteries and $R_{rec,nc,Mat}$ for the non-properly collected fraction. R_{rec,c_Mat} and R_{rec,nc_Mat} values of the default recycling process are provided in Table 2. Company-specific R_{rec,c_Mat} values may be used only for the share of the batteries the CFB declarant is able to provide evidence that the batteries will be recycled in a specific recycling plant and that the specific recycling process corresponds to the battery model for which the CFB is declared. In case of company-sepcific R_{rec,c_Mat} values, they shall be calculated as the ration between the mass of the secondary material produced and the mass of the material entering the recycling process. The corresponding evidence (such as contractual instruments and the number of batteries being recycled under them) shall be provided in the CFB supporting study. Even in the case of company-specific R_{rec,c_Mat}, these may be applied only for the amount of batteries properly collected. In the case of the material recycled from the PWB recycling (copper, gold, silver, and palladium), R_{rec,c_Mat} refer to the kg of material per kg of PWB in input and only the default values provided in Table 2 shall be used.

— R_{3,c_Mat}: the proportion of the material that is used for energy recovery at the end-of-life of the properly collected waste batteries. In the default 'End-of-life' life-cycle stage, only the dismantled polymers from the dismantling goes to energy recovery (i.e., R_{3,c_Mat} = 100% for polymers). For non-properly collected waste batteries, no energy recovery is assumed, so the proportion of the material in the product that is used for energy recovery at the end-of-life is equal to 0 by default. For other materials, R_3 from the Part C of the Annex II of the EF method may be used. When no value is available in the Part C of the Annex II of the EF method, new values may be used for R_{3,c_Mat} if justified in the Supporting Study or R_{3,c_Mat} shall be set to 0%.

— E_{V_Mat}: specific emissions and resources consumed arising from the acquisition and pre-processing of primary material. E_V may be either a most relevant process or a non-most relevant process (section 6.2).

— $E_{recycled\_Mat}$: specific emissions and resources consumed arising from the recycling process of the recycled material. Collection, sorting, and transportation of the waste used to produce the secondary material shall be excluded. $E_{recycled\_Mat}$ can be either a most relevant process or a non-most relevant process (section 6.2).

40 European Commission, Directorate-General for Environment, Mehlhart, G., Kosińska, I., Baron, Y., Hermann, A., Assessment of the implementation of Directive 2000/53/EU on end-of-life vehicles (the ELV Directive) with emphasis on the end-of-life vehicles of unknown whereabouts - Under the Framework Contract : assistance to the Commission on technical, socio-economic and cost benefit assessments related to the implementation and further development of EU waste legislation, Oeko-Institut e.V, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-81311-5, doi: 10.2779/446025.

41 Bobba, S., Marques dos Santos, F., Maury, T., Tecchio, P., Mehn, D., Weiland, F., Pekar, F., Mathieux, F. and Ardente, F., Sustainable use of Materials through Automotive Remanufacturing to boost resource efficiency in the road Transport system (SMART), EUR 30567 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-28645-5, doi:10.2760/84767, JRC123261

The allocation of a multi-material process to the single material shall follow the hierarchy for dealing with multifunctional described in section 7.2. It shall include the management of the waste of the recycling process and the wastewater treatment (when applicable).

- E_{recEoL_Bat}: specific emissions and resources consumed arising from the battery cell recycling. Annex III defines the inputs and outputs of the default battery cell recycling process. To note that E_{recEoL_Bat} is accounted for on battery level and not per material. The default battery cell recycling process is assumed to take place in Europe. Different company-specific recycling processes may be used only with the conditions described for the R_{rec,c_Mat}. In this case, the recyclers may: i) provide all the data, ii) provide a CFB-compliant company-specific dataset to the CFB declarant.
- E_{recEoL_Mat}: specific emissions and resources consumed arising from any additional recycling process that is needed to produce secondary material. In the default 'End-of-life' life-cycle stage, the recycling processes are assumed to take place in Europe (both for the properly collected waste batteries and the non-properly collected waste batteries). For all the outputs of the battery cell recycling process, E_{recEoL_Mat} includes all the additional recycling processes not included in the battery cell recycling (e.g., sorting and re-melting of aluminium scrap into secondary aluminium) and it is equal to 0 in the default battery cell recycling (i.e., no additional recycling is needed).

NOTE: E_{recEoL_Bat} includes all process inputs and direct emissions of the hydrometallurgical and the pyrometallurgical process as described in Annex III. E_{recEoL_Mat} are the specific burdens (carbon footprint) associated with the re-processing of the metal fractions separated during recycling, such as sorting and re-melting of aluminium scrap into secondary aluminium. E_{recEoL_Mat} is zero for all materials that leave the battery cell recycling process as final product i.e., directly replacing the equivalent primary product such as cobalt sulphate or nickel sulphate. $E_{recEoL_{Mat}}$ is not zero for any output of the battery cell recycling process that needs additional processes before being sold as secondary material. (e.g., sorting, cleaning and remelting to metal ingots).

- E_{recEoL_PWB}: specific emissions and resources consumed arising from the PWB recycling following the dismantling of the properly collected batteries. E_{recEoL_PWB} shall always be modelled as a non-most relevant process (section 6.2).
- E^*_v: specific emissions and resources consumed arising from the acquisition and pre-processing of primary material assumed to be substituted by recyclable materials. Ev* shall be equal to Ev.
- Q_{sin}: quality of the ingoing secondary material, i.e., the quality of the recycled material at the point of substitution.
- Q_{Sout}: quality of the outgoing secondary material, i.e., the quality of the recyclable material at the point of substitution.
- Q_p: quality of the primary material, i.e., quality of the primary material.
- Q_{sin} / Q_p: ratio between the quality of the ingoing secondary material and the quality of the primary material. Default values are provided in Table 2.
- Q_{Sout} / Q_p: ratio between the quality of the ingoing secondary material and the quality of the primary material. Default values are provided in Table 2. Higher values are allowed only if a company-specific battery recycling process is modelled and if justified in the CFB supporting study.
- E_{ER}: specific emissions and resources consumed arising from the energy recovery of the polymers from the manual dismantled (for both the properly collected and the non-properly collected waste batteries). E_{ER} shall always be modelled as a non-most relevant process (section 6.2). If the secondary datasets for energy recovery does not include the credits from the production of energy, the CFB declarant shall model it using the lower heating value of the polymers.
- E_D: specific emissions and resources consumed arising from the disposal of waste material at the analysed product's end-of-life, without energy recovery.

For PWB, the CFB declarant shall check if the datasets for PWB recycling already include the credits from the production of secondary material to avoid double accounting. If these datasets are fully aggregated (I.e., the credit for recovered materials is already contained in the LCI data or the LCIA result), the credits for specific materials shall be set to zero.

To apply the CFF correctly along the battery supply-chain, the company-specific R1 of e.g., any raw material, precursos, active material, shall be handed over to the next process step / manufacturer even in case of CFB-compliant company-specific datasets.

Table 2. Default values for the parameters to be used in the default end-of-life (EoL) stage. [a]Company-specific values may be used according to section 7.3.1. [b]These values are to be applied per kg of PWB, since they indicate the mass of each material recovered per kg of recycled PWB. [c] Additional materials may be recycled if a company-specific battery cell recycling process is modelled.

				For the properly collected waste batteries		**For the non-properly collected waste batteries**	
	A_{Mat}	R_{1_Mat}	Q_{sin}/Q_p	R_{rec,c_Mat}	$Q_{Sout,c}/Q_p$	R_{rec,nc_Mat}	$Q_{Sout,nc}/Q_p$
Al metal (from the dismantling)	0.2	0[a]	1	0.9	1	0.9	1
Al metal (cells)	0.2	0[a]	1	0[a]	1	0	1
Cu metal (from the dismantling)	0.2	0[a]	1	0.9	1	0.9	1
Cu metal (cells)	0.2	0[a]	1	0.9[a]	1	0	1
Fe metal (from the dismantling)	0.2	0[a]	1	0.9	1	0.9	1
Fe metal (cells)	0.2	0[a]	1	0[a]	1	0	1
Polymers (from the dismantling)	0.5	0[a]	1	0	0.8	0	0.8
Other materials (from the dismantling)	0.5	0[a]	1	0	N/A	0	N/A
Au from PWB	0.2	0[a]	1	1.40E-5[b]	1	0	1
Cu from PWB	0.2	0[a]	1	0.11[b]	1	0	1
Ag from PWB	0.2	0[a]	1	9.77E-4[b]	1	0	1
Pd from PWB	0.2	0[a]	1	9.31E-8[b]	1	0	1
Co salts (cell)	0.2	0[a]	1	0.9[a]	0.8[a]	0	0.8
Ni salts (cell)	0.2	0[a]	1	0.9[a]	0.8[a]	0	N/A
Mn salts (cell)	0.2	0[a]	1	0[a]	0.8[a]	0	N/A
Li salts (cell)	0.2	0[a]	1	0[a]	0.8[a]	0	N/A
Other metal salts (cell)	0.2	0[a]	1	0.85[a]	0.8[a]	0	N/A

(AAM) Graphite / hard carbon (cell)	0.2	0 [a]	1	0 [a]	0.8 [a]	0	N/A
Others materials (cell)	[c]	0 [a]	[c]	[c]	[c]	0	N/A

Source: JRC analysis.

7.4 Transport

Company-specific activity data for transport shall be used in combination with secondary datasets to calculate the carbon footprint for all the mandatory company-specific processes (section 6.1).

For non-mandatory processes, secondary data may be used and shall be reported reported in the CFB supporting study. In this case, the following default distances shall be used in this case:

— For suppliers located within Europe or within the same country of the manufacturing plant:
  - 130 km by truck.
  - 240 km by train (average freight train).
  - 270 km by ship (barge).

— For all suppliers located outside the country of the manufacturing plant where the material is delivered to (e.g., provider from outside Europe delivers to Europe) or when the provenience is unknown:
  - 1 000 km by truck, for the sum of distances from the harbour to customer outside and inside Europe.
  - 18 000 km by ship (transoceanic container).

If the producer’s country (origin) is known: the adequate distance for ship shall be determined and its source be provided in the CFB supporting study.

The CFB declarant shall state which transport type is modelled in the CFB supporting study.

8 Verification

The verification of the CFB shall be carried out in compliance with the general requirements included in the Battery Regulation Proposal.

In particular:

- The verification shall cover all the details specified in the following sections.
- The verification shall cover at least the points as specified in the EF method (Annex II – Section 8.4).

8.1 Application for verification

The CFB declarant shall lodge an application for verification of the CFB to a notified body according to the Battery Regulation Proposal.

The application shall make it possible to understand the design, material composition and manufacture of the product, as well as all steps taken, and data used in the calculation of the carbon footprint. It shall include at least:

- The name and address of the CFB declarant and, if the application is lodged by the authorised representative, his name and address as well.
- A written declaration that the same application has not been lodged with any other notified body.
- The carbon footprint calculated in line with the present carbon footprint rules.
- The technical documentation described in section 8.2.

The notified body may request further information if needed.

The notified body shall verify and validate the application to determine whether the declared carbon footprint and the supporting information is reliable, credible and correct.

8.2 Technical documentation

The CFB declarant shall produce a CFB supporting study that shall document in a systematic, orderly and comprehensive manner all steps taken in the CFB.

The technical documentation includes the public version of the CFB supporting study (section 8.2.1)and the non-public version of the CFB supporting study (section 8.2.2). The public version of the CFB supporting study shall be available online in line with the Article 7 (section 1, point g) of the Battery Regulation Proposal.

8.2.1 Public version of the CFB supporting study

The public version of the CFB supporting study shall at least contain:

- An unambiguous description of the product for which the CFB declaration is valid, including its origin and a unique identifier.
- Reference year (for which the CFB declaration was elaborated).
- The total CFB declared per FU (g CO_2 eq/kWh).
- The DQR score and the values of the single DQR criteria calculated as in section 6.5.
- The contribution of each life-cycle stage ('Raw materials and pre-processing', 'Manufacturing', 'Distribution', and 'End-of-life') to the total CFB of the battery per FU (in gCO2eq/kWh).
- The CFB per kWh of rated energy capacity (kg CO_2eq/kWh).
- The rated energy capacity of the battery in kWh.
- The service life used for the calculation of the total energy provided over lifetime, expressed in number of cycles and the cycle life test used for determining the service life.
- The end-of-life SOCE or remaining useable energy capacity of the service life test.
- The total energy (total energy provided by the battery over its service life as used for the CFB calculation) in kWh.

— The average discharge depth during each cycle of the cycle life test and the average amount of delivered energy over each cycle.

— The service life used for the calculation of the total energy provided over lifetime, expressed in km (if applicable).

— The energy consumption of the corresponding Part B vehicle family used for calculating the total energy (if applicable).

— The implementation of a virtual housing approach and its justification.

8.2.2 Non-public version of the CFB supporting study

The non-public version of the supporting study is a confidential document filed by the CFB declarer that shall be available to the notified body. It coincides with the confidential meta-data in case of a CFB-compliant datasets. It shall be kept and made be available on request by at least 5 years more than the expected lifetime of the battery and, anyway, no less than 15 years after putting the battery on the market.

The non-public version of the supporting study shall at least include detailed description and documentation of:

— All information contained in the public vesion of the CFB supporting study (if applicable).

— The model used for the CFB calculation.

— Any cut-off applied in the modelling, the resulting mass balance gap and an indication to which activity data / dataset the missing mass is assigned.

— The functional unit (i.e., the total energy provided by the battery over the battery's service life) and all the information needed to calculate it (e.g, the service life, the energy discharged from the battery per unit of distance driven for light-duty EV batteries, the parameters used to calculate the discharged energy per km for light-duty EV batteries, the delivered energy for category L (motorcycle) EV batteries, the battery energy capacity for medium-duty and heavy-duty EV batteries, the average amount of delivered energy over each cycle for all the other EV batteries under the Article 7 of the Battery Regulation Proposal, and the usable energy capacity).

— The details of all the company-specific data, including:

  - A table containing all activity data and elementary flows, the corresponding background dataset used (if applicable) and the values of the DQR criteria of each dataset. The Tables shall follow the data collection table structure provided in Annex II, including the bill of materials and/or ingredients (e.g., substance names, units and quantities, information on origin, grades/ purities, recycled content and other technically and/or environmentally relevant characterisation of these), the procedure used for company-specific data collection/estimation/calculation, the data source (if applicable), the data collection period, and the corresponding justification if data collection is done for periods of time other than specified in the CFB Rules.
  - To which life-cycle stage they belong
  - If they have been used for modelling the mandatory company-specific or non-mandatory company-specific processes
  - Any underlying documentation needed to establish the reliability of the company-specific data.

— The details of all the datasets (both secondary and CFB-compliant company-specific) used in the CFB, including:

  - How the most relevant processes have been modelled (i.e., with secondary datasets or CFB-compliant company-specific datasets), which datasets have been used, when the electricity in the '-1 level' was changed and the justification for such change (if applicable). If company-specific datasets are used for most relevant processes, a justification of the need for own modelling and the corresponding evidence. For the most relevant processes in the 'Raw material acquisition and pre-processing' life-cycle stage, the reference flow, the specific concentration on the target metal, and other elements included (concentration or specific metal content) shall be reported to allow a proper mass balance check.
  - For all secondary datasets (used in both the mandatory and non-mandatory company-specific processes) the exact name of the dataset, the source, its uuid, location, dataset type type (LCI

result / partially terminated), the values of the DQR criteria (TeR, GeR, TiR) calculated as in section 6.5, and the validity shall be indicated. A justification shall be provided is a secondary dataset not in the 'CFB' node is used in the CFB and their individual contribution to the CFB.

- For all the CFB-compliant company-specific datasets, (used in both the mandatory and non-mandatory company-specific processes) the exact name of the dataset, its uuid, location, dataset type type (LCI result / partially terminated), the values of the DQR criteria (TeR, GeR, TiR) calculated as in section 6.5, and the validity shall be indicated.

— The details of how the electricity was modelled, including:

- Which electricity model has been used for each process.
- Evidence of the values used for on-site generated electricity.
- Evidence of the values used for the supplier-specific electricity product, including the composition of the residual consumption mix, the data source, and how it has been modelled.
- Which datasets have been used to model the residual consumption mix and the average consumption mix.

— The details of how the allocation was applied, including:

- The multifunctional processes for which an allocation was needed
- The type of allocation chosen (subdivision, allocation based on physical relationships, or economic allocation) and a justification.
- In case of allocation based on physical relationships, which physical relationship has been used and a justification.
- In case of economic allocation, the prices and the corresponding sources including the considered timespans used for the economic allocations.
- The datasets / activity data to which the allocation factors apply shall be indicated in the inventory tables.
- If allocation is done for energy and auxiliary inputs of production lines, the chosen method and a justification.
- The implementation of the virtual housing approach, including all assumptions and dimensioning parameters used, a tabulated mass balance of the real housing and of the virtual housing and the carbon footprint of the battery when using the real housing.

— The detailed of the recycled content and 'End-of-life' modelling, including:

- The parameters used in the CFF for all materials with a justification when non-default parameters were used.
- In case a recycled content different than 0, the evidence of the treaceability of the supply-chain.
- In case of a company-specific collection rate, the evidence that a share of the batteries are covered by an ownership business model.
- In case of a company-specific battery cell recycling process, the evidence that the batteries will be recycled in a specific recycling plant and that the recycling process corresponds to the batter model for which the CFB is declared.

— All the limitations of the CFB.

Optionally, the public version of the CFB supporting study may contain information about additional services provided by the battery in a tabulated format (not more than 5 words per additional service).

Where necessary, information provided to verifiers shall include confidential information. Confidential information shall be used only during the verification process.

8.2.3 Additional requirements for meta-data information in CFB compliant datasets

No public supporting study needs to be disclosed in case of CFB-compliant datasets. However, the meta-data of the datasets shall be available to the notified body and to the CFB-declarant.

In case of CFB-compliant company-specific datasets, no public version of the CFB supporting study needs to be disclosed. Instead, an additional non-public report shall be prepared and provided to the CFB declarant. Suche report shall contain all information needed by the CFB declarant / the subsequent economic agent for incorporating the dataset into its CFB model and declaration.

It shall at least contain:

- An unambiguous description of the product for which the intermediate CFB declaration is valid, including its origin and a unique identifier
- The total CFB declared per unit of mass (kg CO_2eq/kg) or per unit of energy (kg CO_2eq/kWh).
- If applicable, a break-down to life-cycle stages as defined in Section 4
- Relevant parameters related with the quality of the product (such as purity, specific capacity, etc.)
- Specific content of metals that are targeted by the standard recycling process models according to Annex III, at least Steel, Aluminium, Copper, Cobalt (sulphate), Nickel (sulphate), Manganese (sulphate), Lithium, graphite, silicon, titanium, vanadium, silver, gold and platinum group metals

8.3 Verification and validation techniques

The notified body shall verify that:

- The data and information used for the calculation of the carbon footprint are consistent, reliable and traceable; and
- Any calculations performed is correct.

The notified body shall combine review of the documentation (described in section 8.2) and validation of the model used to calculate the carbon footprint of the battery. In particular, the notified body shall access the model to verify its structure, the data used, and its consistency with the carbon footprint supporting study.

The review of the documentation includes the the non-public version of the supporting study and public version of the supporting study, through available or requested underlying documentation. The notified body may organise the documental review either as an “at desk” or “on site” exercise, or as a mix of the two. The verification of the company-specific data may be organised through a visit of the production site(s) the data refer to. For batteries manufactured in series, it shall include an assessment visit to the manufacturer's premises.

The notified body shall as a minimum:

- Ensure that all secondary datasets used in the model are appropriate and in compliance with the requirements laid out in the present rules for CFB;
- Ensure that the verification of company-specific data includes:
  - Coverage, precision, completeness, representativeness, consistency, reproducibility, sources and uncertainty;
  - Plausibility, quality and accuracy of the data;
  - Quality and accuracy of the underlying documentation.
- Ensure the correct application of the electricity modelling rules as prescribed in the present rules for CFB;
- Assess and confirm whether the calculations are of acceptable accuracy, reliable, are appropriate and performed in accordance with the CFB rules specified in this document
- Confirm the correct application of conversion of measurement units;
- Evaluate whether the methods for making estimates are appropriate and have been applied consistently;
- Assess alternatives to estimations or choices made to determine whether a conservative choice has been selected;
- Identify uncertainties that are greater than expected and assess the effect of the identified uncertainty on the CFB results.

8.4 Data confidentiality

Data for verification shall be presented to the notified body in a systematic and comprehensive way. All the documentation supporting the validation shall be provided to the notified body, including the CFB model, confidential information, data, and the CFB supporting study(s) (including the public version of the CFB supporting study). The notified body shall treat all information and data undergoing verification as confidential and shall use them only during the verification process.

The CFB supporting study may exclude confidential data and information, provided that:

- Only input information is excluded and all output information is included.
- It provides the notified body with sufficient information of the nature of the data and information excluded, as well as the reasoning for excluding them.
- The notified body shall evaluate whether the non-disclosed information hinders the review of the CFB.
- The CFB declarant keeps a file of the non-disclosed information for possible future re-evaluation of the decision for non-disclosure.

NOTE: Business data could be of confidential nature because of competition aspects, intellectual property rights or similar legal restrictions. Therefore, business data identified as confidential and provided during the verification process can be kept confidential. Hence, the notified body will not disseminate or otherwise retain for use, without the organisation's permission, any information disclosed to them during the course of the verification process. The CFB declarant could ask the notified body and its verifier(s) to sign a non-disclosure agreement (NDA).

Confidential information and data shall not be included in the public version of the CFB supporting study.

9 Conclusions

The present report proposes some rules for determining the carbon footprint of electric vehicle batteries, in line with the requirements of the EU Battery Regulation Proposal. It aims at aligning as much as possible with the ongoing PEFCR, but still keeping some general approach that would allow the application of the CFB rules also for batteries currently not in the market but potentially available in the very next future. The CFB rules has been the result of an extensive exchange with a large number of stakeholders and may be considered as a consensus building of different opinions upon the calculation of carbon footprint for EV batteries.

This document is intended to provide the technical basis for the building of the first round of Delegated Act as under the article 7 of the Battery Regulation Proposal.

List of abbreviations

BMS	Battery Management System
BoL	Beginning of Life
CFB	Carbon Footprint of Batteries
CFF	Circular Footprint Formula
DNM	Data Needs Matrix
DPRi	Declared Performance Requirement
DQR	Data Quality Rating
EF	Environmental Footprint
EoL	End-of-life
EPLCA	European Platform for Life-cycle Assessment
EV	Electric Vehicle
FCHV	Fuel cell hybrid vehicles
GWP100	Global Warming Potential 100-years
GO	Guarantee of Origin
HEV	Hybrid Electric Vehicle
ILCD	International Life-cycle Data
JRC	Joint Research Centre
LCI	Life-cycle Inventory
LCIA	Life-cycle Impact Assessment
LCDN	Life-cycle Data Network
LMT	Light Means of Transport
MPRi	Minimum Performance Requirement
OEM	Original Equipment Manufacturer
OVC-HEV	Off-Vehicle Charging Hybrid Electric Vehicle
NOVC-HEV	Not Off-Vehicle Charging Hybrid Electric Vehicle
PEF	Product Environmental Footprint
PEFCR	Product Environmental Footprint Category Rules
PEV	Pure Electric Vehicle
PWB	Printed Wiring Board
SoC	State of Charge
SOCE	State of Certified Energy
SOCR	State of Certified Range
UN GTR	United Nations Global Technical Regulation
UUID	Universal Unique IDentifier
WLTP	Worldwide Harmonised Light Vehicle Test Procedure
WMTC	Worldwide Harmonised Motorcycle Testing Cycle

List of definitions

‘Accreditation’ means accreditation as defined in Article 2(10) of Regulation (EC) No 765/2008 (Article 2 of the Battery Regulation Proposal).

‘Active Material’ refers to the materials within the battery material which react chemically to produce electric energy when the battery cell discharges or to store electric energy when the battery is being charged. They are the main constituents of the anode and cathode, respectively. For lithium-ion batteries, anode active materials are typically graphites, sometimes doped with silicon, or spinels such as lithium titanate. Cathode active materials (CAM) are typically layered oxides such as NMC or NCA, but also polyanionic materials such as LFP

‘Active Material Precursor’ are materials required for the synthesis of active materials, such as lithium salts (carbonates or hydroxides) and cobalt, nickel and manganese salts (most commonly sulphates) for the synthesis of NMC active materials

‘Activity data’ means the information associated with processes while modelling Life-cycle Inventories (LCI). The aggregated LCI results of the process chains that represent the activities of a process are each multiplied by the corresponding activity data and then combined to derive the carbon footprint associated with that process (Annex II of the Battery Regulation Proposal).

‘Aggregated dataset’ means life-cycle inventory (LCI) of multiple unit processes (e.g. material or energy production) or life-cycle stages (cradle-to-gate), but for which the inputs and outputs are provided only at the aggregated level. NOTE: Aggregated datasets are also called "LCI results", “cumulative inventory” or “system processes” datasets.

‘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 of packs of them, including a battery that has been subject to preparing for re-use, preparing for repurpose or repurposing, or remanufacturing (Article 2 of the Battery Regulation Proposal).

‘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 (Article 2 of the Battery Regulation Proposal).

‘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 mean of transport or appliance in which the battery is incorporated, or with a public or private charging infrastructure (Article 2 of the Battery Regulation Proposal).

‘Battery manufacturing waste’ means 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 (Article 2 of the Battery Regulation Proposal).

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

‘Battery pack’ means any set of battery cells or modules that are connected together or encapsulated within an outer housing, so as to form a complete unit that the end-user is not intended to split up or open (Article 2 of the Battery Regulation Proposal).

‘Battery system’ refers to batteries of any configuration subject to a mandatory CFB declaration under the Article 7 of the Battery Regulation Proposal. In this report, the term ‘battery’ is used as equivalent.

‘Battery due diligence’ means the obligations of the economic operator, in relation to its management system, risk management, third party verifications and surveillance by notified bodies and disclosure of information with a view to 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 including suppliers in the chain and their subsidiaries or subcontractors that perform such activities (Article 2 of the Battery Regulation Proposal).

‘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 (Article 2 of the Battery Regulation Proposal).

‘Bill of materials’ means list of the raw materials, sub-assemblies, intermediate assemblies, sub-components, parts and the quantities of each needed to manufacture the product in scope of the study (Battery Regulation Proposal - Annex II).

‘Carbon footprint’ means the sum of greenhouse gas (GHG) emissions and GHG removals in a product system, expressed as carbon dioxide (CO2) equivalents and based on a Product Environmental Footprint (PEF) study using the single impact category of climate change (Article 2 of the Battery Regulation Proposal).

‘CFB declarant’ means the legal subject/entity that has the obligation to declare the CFB according to the Battery Regulation Proposal.

‘CFB-compliant company-specific dataset’ means a company-specific dataset that respects the requirements defined in section 6.3. A CFB-compliant company-specific dataset can be either a LCI dataset or a LCIA dataset

‘Characterisation factor’ means a factor derived from a characterisation model which is applied to convert an assigned life-cycle inventory result to the common unit of a LCIA impact category.

‘Circular Footprint Formula’ describes how burdens and benefits from disposal and recovery of the product or service assessed as well as use of secondary materials (i.e., recycled content) into that product or service are allocated to the system under study.

‘Climate change’ is the LCIA impact category considering all inputs and outputs that result in greenhouse gas (GHG) emissions. The consequences include increased average global temperatures and sudden regional climatic changes.

‘Company-specific data’ refers to directly measured or collected data from one or multiple facilities (site-specific data) that are representative for the activities of the company. It includes company-specific activity data and elementary flows. It is synonymous to 'primary data' (Annex II of the Battery Regulation Proposal) or ‘supply-chain specific data’ or ‘manufacturer-specific’ data.

‘Company-specific dataset’ means a dataset (disaggregated or aggregated) compiled with company-specific data. The actvity data and direct elementary exchanges of company-specific data sets shall refer to company-specific information, while the underlyin sub-processes may be modelled with company-specific or secondry datasets.

‘Conformity assessment’ means the process demonstrating whether the sustainability, safety, labelling, information or due diligence requirements of this Regulation have been fulfilled (Article 2 of the Battery Regulation Proposal).

‘Conformity assessment body’ means a body that performs conformity assessment activities including calibration, testing, certification and inspection (Article 2 of the Battery Regulation Proposal).

‘Data’ includes activity data and elementary flows.

‘Data collection period’ means the date(s) or time period(s) when the data was collected. Note that this does NOT refer to e.g., the publication dates of papers or books from which the data may stem, but to the original data collection period.

‘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 (Article 2 of the Battery Regulation Proposal).

‘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 reuse, preparing batteries for repurpose, repurposing, or remanufacturing, of batteries, making them available or placing them on the market, including on-line placing on the market, or putting them into service in accordance with this Regulation (Article 2 of the Battery Regulation Proposal).

‘EF-compliant dataset’ means dataset developed in compliance with the EF requirements in terms of modelling and methodological compliance (in agreement with the “Commission Recommendation (EU)

2021/2279"); meta data compliance (in agreement with Fazio et al. 2020, "Guide on EF compliant datasets"); nomenclature, and characterization factors in agreement with the "EF 3.1 Reference Package"). The DQR of each single data quality indicator shall be lower or equal than 3.

'Elementary flows' or 'direct elementary flows' include 'material or energy entering the system being studied that has been drawn from the environment without previous human transformation, or material or energy leaving the system being studied that is released into the environment without subsequent human transformation'. Elementary flows include, for example, resources taken from nature or emissions into air, water, soil that are directly linked to the characterisation factors of the EF impact categories.

'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 (Article 2 of the Battery Regulation Proposal).

'Functional unit' means the qualitative and quantitative aspects of the function(s) and/or service(s) provided by the product being evaluated (Article 2 of the Battery Regulation Proposal).

'Harmonised standard' means a standard as defined in Article 2(1)(c) of Regulation (EU) No 1025/2012 (Article 2 of the Battery Regulation Proposal).

'ILCD entry-level compliant dataset (ILCD-EL)' means a dataset developed in agreement with the ISO 14040 and 14044 in terms of methodological compliance; in agreement with "International Reference Life-cycle Data System (ILCD) Data Network - Compliance rules and entry-level requirements" in terms of meta data compliance; in agreement with the "EF 3.1 Reference Package" for nomenclature and characterization factors compliance.

'Industrial battery' means any battery: - designed specifically for industrial uses, or – intended for industrial uses after being subject to preparing for repurpose or repurposing, or – any other battery with a weight above 5 kg that is not a LMT battery, an electric vehicle battery or a SLI battery (Article 2 of the Battery Regulation Proposal).

'Importer' means any natural or legal person established within the Union who places a battery on the market from a third country (Article 2 of the Battery Regulation Proposal).

'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 (Article 2 of the Battery Regulation Proposal).

'Intermediate product' means the output form of a unit process that in turn is input to other unit processes which require further transformation within the system. An intermediate product is a product that requires further processing before it is saleable to the final consumer

'Life-cycle' means the consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final disposal (ISO 14040:2006 or equivalent) (Article 2 of the Battery Regulation Proposal).

'Life-cycle assessment (LCA)' means the compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life-cycle.

'Life-cycle inventory (LCI)' means the combined set of exchanges of elementary, waste and product flows in a LCI dataset.

'Life-cycle inventory (LCI) dataset' means a document or file with life-cycle information of a specified product or other reference (e.g., site, process), covering descriptive metadata and quantitative life-cycle inventory. A LCI dataset could be a unit process dataset, partially disaggregated or an aggregated dataset.

'Life-cycle inventory (LCI) results' means the quantitative assessment of the inputs and outputs associated with the life-cycle of a product, process, or system. LCI results provide detailed information about the environmental exchanges and resource consumption throughout the entire life-cycle, including the extraction of raw materials, manufacturing, transportation, use, and disposal. By following the supplies of intermediate inputs of each dataset and cumulating the environmental exchanges of these interlinked datasets.

'Life-cycle impact assessment (LCIA)' is a phase of the life-cycle assessment that aims to understand and evaluate the magnitude and significance of the potential environmental impacts for a system throughout the life-cycle. The LCIA methods provide impact characterisation factors for elementary flows to aggregate the impact, to obtain a limited number of midpoint and/or damage indicators.

'Life-cycle impact assessment (LCIA) dataset' means a document or file with life-cycle information of a specified product or other reference (e.g., site, process), covering descriptive metadata and quantitative life-cycle impact assessment results.

'Life-cycle impact assessment (LCIA) result' means the result of the impact category indicators in the LCIA phase (e.g., if climate change is the only impact category analysed, the LCIA result is the carbon footprint of the product or system in kg CO2 eq).

'Light means of transport battery' or 'LMT battery' means any battery that is sealed and weights below or equal to 25 kg, designed to provide electric power for the 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. (Article 2 of the Battery Regulation Proposal).

'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 (Article 2 of the Battery Regulation Proposal).

'Manufacturer' means any natural or legal person who manufacturers 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 (see Article 2 of the Battery Regulation Proposal).

'Most representative secondary dataset' means the dataset having the highest Technological Representativeness (TeR) according to section 6.5. If there are several datasets with the same calculated TeR, the one with the highest Geographical Representativeness (GeR) according to section 6.5 shall be selected. In the absence of information on the geographical provenience of the material, the global average shall be used.

'National accreditation body' means a national accreditation body as defined in Article 2(11) of Regulation (EC) No 765/2008 (see Article 2 of the Battery Regulation Proposal).

'Notified body' means a conformity assessment body notified in accordance with Chapter V of this Regulation (see Article 2 of the Battery Regulation Proposal).

'Partially disaggregated dataset' means a dataset with a LCI that contains elementary flows and activity data, and that only in combination with its complementing underlying datasets yield a complete aggregated LCI dataset.

'Partially disaggregated dataset at -1 level' is a partially disaggregated dataset that contains elementary flows and activity data for one level down in the supply-chain, while all complementing underlying datasets are in their aggregated form

'Placing on the market' means the first making available of a battery on the Union market (A Article 2 of the Battery Regulation Proposal).

'Rechargeable battery' means a battery that is designed to be electrically recharged (Article 2 of the Battery Regulation Proposal).

'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.

'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 (see Article 2 of the Battery Regulation Proposal).

'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, alternatively: (i) is established in a Member State and manufactures batteries under its own name or trademark, or has batteries designed or manufactured and supplies them for the first time under its own name or trademark, including those incorporated in appliances, light means of transport or vehicles, within the territory of that Member State; (ii) is established in a Member State and resells within the territory of that Member State, under its own name or trademark, batteries, including those incorporated in appliances, light means of transport or vehicles, manufactured by others. A reseller is not regarded as the 'producer' if the brand of the manufacturer appears on the batteries, as provided for in point (i); (iii) is established in a Member State and supplies for the first time in this Member State on a professional basis, batteries, including those incorporated in appliances, light means of transport or vehicles, from a third country or from another Member State; (iv) sells batteries, including those incorporated in appliances, light means of transport or vehicles, by means of distance communication directly to end-users, that are either private households or other than private households, in a Member State, and is established in another Member State or in a third country. (Article 2 of the Battery Regulation Proposal).

'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 (Article 2 of the Battery Regulation Proposal).

'Rechargeable battery' means a battery that is designed to be electrically recharged (Article 2 of the Battery Regulation Proposal).

'Recycler' means any natural or legal person who carries out recycling in a permitted facility (Article 2 of the Battery Regulation Proposal).

'Recycling efficiency' of a recycling process means the ratio obtained by dividing the mass of output fractions accounting for recycling by the mass of the waste batteries input fraction, expressed as a percentage (Article 2 of the Battery Regulation Proposal).

'Reference flow' means the measure of the outputs from processes in a given product system required to fulfil the function expressed by the functional unit.

'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, and results in the battery being used for the same purpose or application than the one for which the battery was originally designed (Article 2 of the Battery Regulation Proposal).

'Representative dataset' means a dataset having a DQR for technological representativeness (TeR) less or equal to 2 and DQR for temporal and geographical representativeness (TiR and GR) lower and equal than 3.

'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 (Article 2 of the Battery Regulation Proposal).

'Residual consumption mix' is the energy source mix that is left over once the reliably tracked consumption is taken out from the generation mix. The residual consumption mix is used where an end-user is sourcing electricity from unknown origin: the energy source mix of it shall be considered as residual consumption mix. A residual consumption mix is an integral part of an energy certificate system for disclosure towards consumers, in order to prevent double counting in energy source disclosure.

'Secondary data' means data not from a specific process within the supply-chain of the company performing a carbon footprint study. This refers to data that is not directly collected, measured, or estimated by the company, but sourced from a third party LCI database or other sources. Secondary data includes industry average data (e.g., from published production data, government statistics, and industry associations), literature studies, engineering studies and patents, and may also be based on financial data, and contain proxy data, and other generic data.

'Secondary datasets' refers to any dataset that is not company-specific, e.g., from a database.

'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; Starting, lighting and ignition (Article 2 of the Battery Regulation Proposal).

‘State of charge’ means the available energy in a battery expressed as a percentage of rated capacity as declared by the manufacturer (Article 2 of the Battery Regulation Proposal).

‘State of health’ means a measure of the general condition of a rechargeable battery and its ability to deliver the specified performance compared with its initial condition (Article 2 of the Battery Regulation Proposal).

‘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 (Article 2 of the Battery Regulation Proposal).

‘System boundary’ indicates which aspects is included or excluded from the life-cycle study (Annex II of the Battery Regulation Proposal). The system boundary defines which parts of the product life-cycle and which associated life-cycle stages and processes belong to the analysed system (i.e. are required for carrying out its function as defined by the functional unit), except for those processes excluded based on the cut-off rule.

‘Technical specification’ means a document that prescribes technical requirements to be fulfilled by a product, process or service (Article 2 of the Battery Regulation Proposal).

‘Technological proxy dataset’ means process dataset describing an alternative product for which process data exist and it is assumed to have similar carbon footprint to the process in scope. Suitable proxy process datasets may differ for technological scope from the target process, but it shall involve the same life-cycle stages.

‘Technologically representative secondary dataset’ means that the secondary dataset has a Technological Representativeness (section 6.3.4) ≤ 4.

‘Regional storage’ physical place, located in the EU, where batteries are stored before they are transported to the place of installation.

‘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’ (Article 2 of the Battery Regulation Proposal).

‘Tracking system’ (electricity) means a system applying the process of assigning electricity generation attributes to electricity consumption.

‘Unit process’ means the smallest element considered in the LCI for which input and output data are quantified (based on ISO 14040:2006).

‘Useable energy capacity’ means the energy discharge capacity of the battery that can effectively be discharged from the battery under consideration of the limitations set by the BMS (such as maximum depth of discharge for increasing lifetime).

‘Waste battery’ means any battery which is waste within the meaning of Article 3(1) of Directive 2008/98/EC (Article 2 of the Battery Regulation Proposal).

The definitions of ‘waste’, ‘waste holder’, ‘waste management’, ‘prevention’, ‘collection’, ‘separate collection’, ‘extended producer responsibility scheme’, ‘reuse’, ‘preparing for re-use’, ‘material recovery’ and ‘recycling’ laid down in Article 3 of Directive 2008/98/EC shall apply (Article 2 of the Battery Regulation Proposal).

The definitions of ‘market surveillance’, ‘market surveillance authority’, ‘fulfilment service provider’, ‘corrective action’, ‘end-user’, ‘recall’ and ‘withdrawal’, as well as of ‘risk’ in relation to requirements of Chapters I, IV, VI, VII, IX and Annex V, Annex VIII and Annex XIII, laid down in Article 3 of Regulation (EU) 2019/1020 shall apply (Article 2 of the Battery Regulation Proposal).

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Annex 1. Data collection requirements – Raw material acquisition and pre-processing

This section describes the generic data collection procedure for the 'Raw material acquisition and pre-processing' life-cycle stage. The data collection requirements for this life-cycle stage only apply if company-specific CFB datasets are developed according to the guidelines provided in Section 6.

The specific production processes / technologies of each metal / metal salt / metal product may include the following generic process steps:

— Mining

— Beneficiation / ore processing (from ore to concentrate)

— Primary extraction (pyrometallurgical or hydrometallurgical)

— Refining

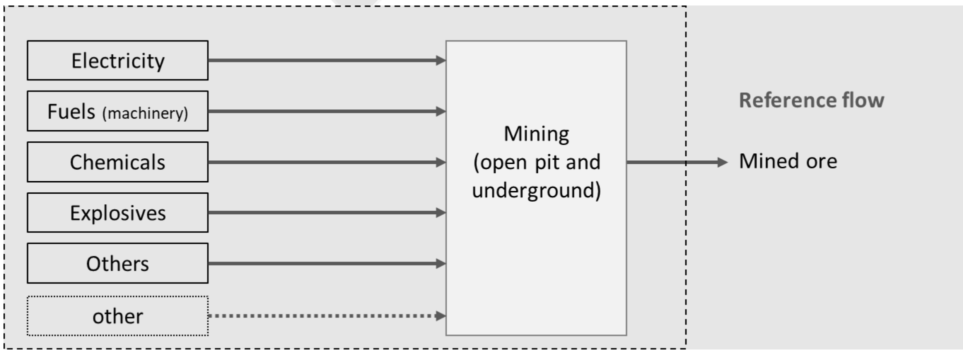
— Finishing

Each of the above-mentioned generic production steps shall have a reference to which all inputs and outputs are referred to (their corresponding reference flow), as shown generically from Figure 4 to Figure 8. The light grey shaded process displays the company-specific activity data of the production process, and the dark grey flow the principal process input (linking it to the previous process that produced it). The other input flows refer to secondary datasets for the purchased goods and services, using company-specific activity data.

It is important that for the main reference flows, the specific concentration data on the target metal and other elements included (concentration or specific metal content) are reported with the reference flows to allow a proper mass balance check.

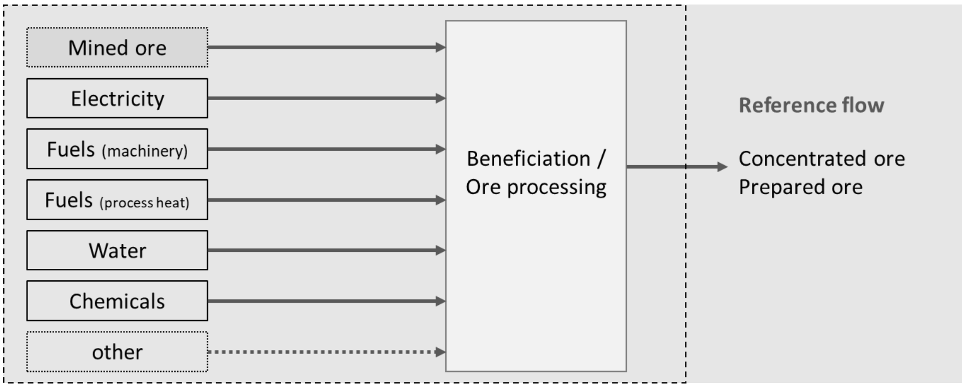
In case materials or components (such as ore concentrates or mattes) are produced in several locations for a specific output material (e.g., nickel sulphate), the data shall be collected for all locations, and a weighted average shall be calculated.

Figure 4. Generic mining process



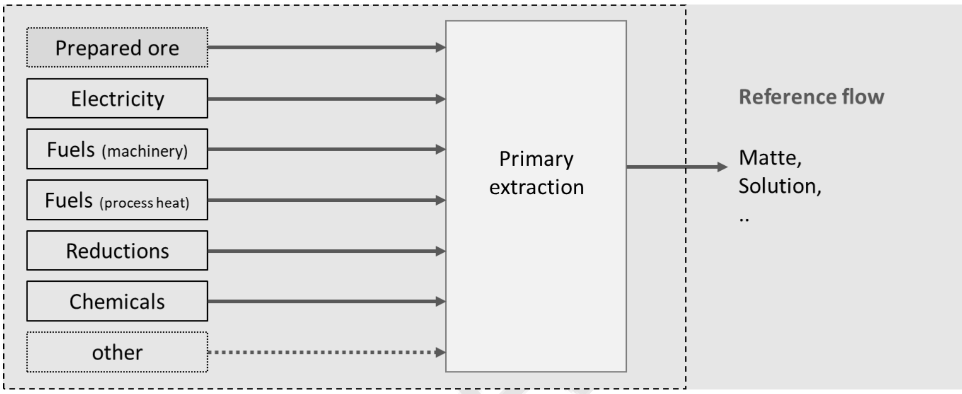
Source: JRC

Figure 5. Generic beneficiation process



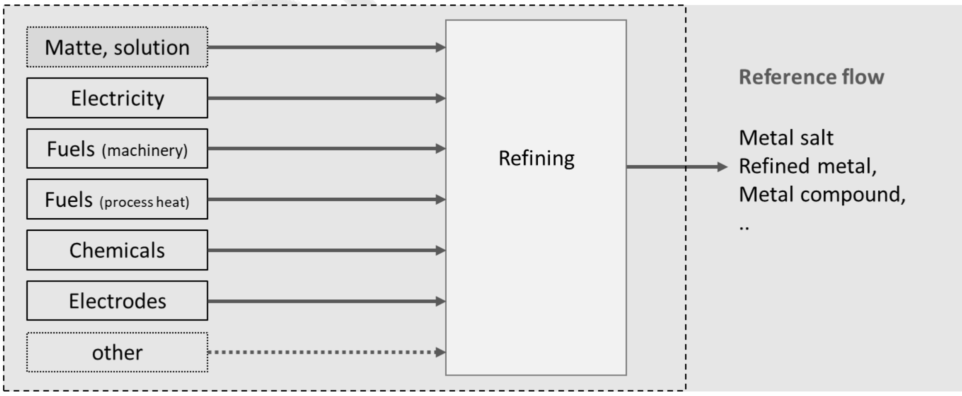
Source: JRC.

Figure 6. Generic primary extraction process



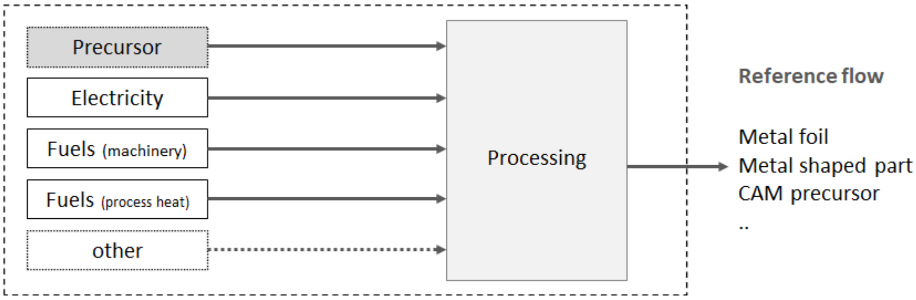
Source: JRC.

Figure 7. Generic refining process



Source: JRC.

Figure 8. Generic finishing process. CAM: cathode active material.



Source: JRC.

The data collection for each of the process stages may then be done with the help of Table 3.

NOTE: Table 3 is only indicative; the general structure and content of the Data Collection Tables as to be provided in the supporting study in this case shall correspond to the structure of the collection tables provided in Annex II.

Table 3. Generic data collection template for the 'Raw material acquisition and pre-processing' stage.

Material	**Unit**	**Data**	**Specification**
Input			
Main input (ore, matte, etc.)			Empty in case of company-specific mining
Electricity			According to section 7.1
Fuels for transport and machinery			E.g., Diesel / LNG / hydrogen
Fuels for (process) heat generation			E.g., Natural Gas, coal / hydrogen
External heat supply (Heat & Steam respective of fuel)			If heat is sourced externally
Explosives			
Filling or structural material (for production)			E.g., cement for backfilling
Acids			E.g., sulphuric acid for acid leaching
Sulphur / H2S			For on-site sulphuric acid production
Neutralizer or slagging agents			E.g., lime, limestone, NaOH, MgO etc..
Electrodes			E.g., graphite electrodes
Reductants			E.g., Coal, charcoal, hydrogen
Chemicals			Bulk chemicals (e.g., frother, dispersants or flocculants). Other chemicals may be aggregated and added to the major bulk chemicals
Tires			For specific machines (mining stage)
Technical gases			E.g., nitrogen, oxygen, etc., if purchased externally

Grinding media			E.g., steel balls / rods (high Cr steel ~10% and low Cr steel)
Transport (of input materials).			E.g., truck, train, bark, etc. Standard distances may be used
Output			
Main product			E.g., ore mined, matte, concentrated ore, final metal (salt), battery grade graphite, intermediate product, assay data to be provided for specific metal contents / concentrations of ores / minerals and intermediate products
By-products			e.g., sulphuric acid, other metals / metal salts than the main product. Allocation according to section 7.2
Overburden			
Waste rock			
CO_2 (fossil) and other GHG emissions			Based on Fuels & Explosives (if combustion emissions are not considered in the corresponding fuel / energy dataset), reductants, electrodes and other reactions where CO_2 emissions occur (e.g., neutralization or precipitation with limestone)

Source: JRC analysis.

For multi-output processes (e.g., more than one metal product is obtained), the allocation shall be done as defined in section 7.2.

Other important inputs to be considered (as indicated in Table 3) are cement, required within the production of the base metal (e.g., cement used for backfilling tailings into mine), electrodes and corresponding carbon emissions (e.g., for reduction of metal salts), explosives for mining and other auxiliaries. Process emissions of CO_2 and other GHG from chemical reactions shall be quantified from reaction stoichiometry (e.g., precipitation or neutralization with limestone, carbon electrodes, reduction processes with coke, ..). If acids are obtained as by-product from emission abatement, subdivision shall be used according to the allocation hierarchy..

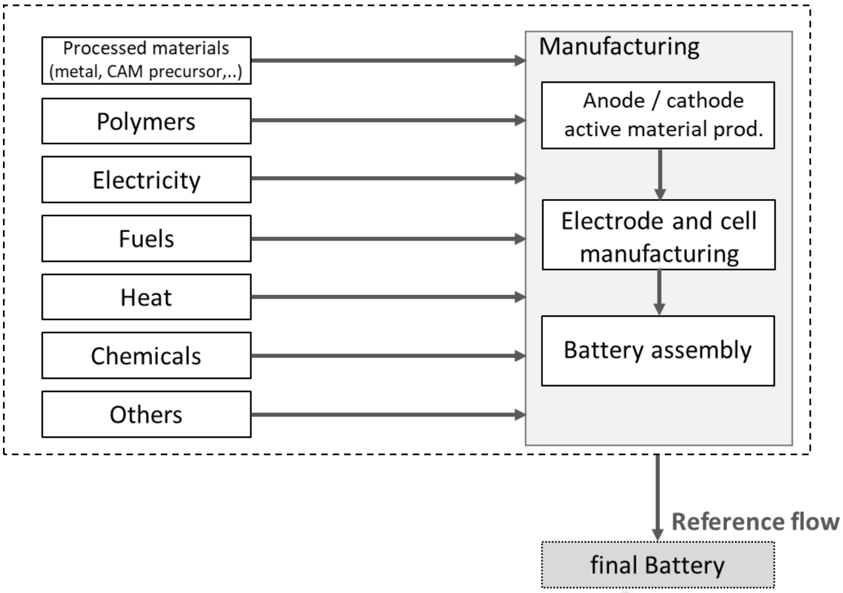
Since many specific chemicals are typically used without a corresponding secondary dataset being available, these may be aggregated in terms of mass and be accounted for together with the bulk chemicals. For instance, in the beneficiation stage all chemicals may be accounted for as ‘frother, dispersants, and flocculants’, which typically take the biggest contributor (mass), using this as a proxy for all categorised chemicals. Grinding media shall be collected even if it might fall under the cut-off criteria.

Annex 2. Data collection requirements – Manufacturing

The ‘Manufacturing’ life-cycle stage includes the production of anode and cathode, battery cells (and components) and the assembly of the final battery (Figure 9).

Scrap rates shall be considered in each process stage separately, accounting for the increased material input due to scrap and manufacturing waste losses and for the corresponding scrap/waste treatment, including the corresponding recycling credits according to the CFF (section 7).

Figure 9. Generic battery manufacturing process



A.2.1 Cathode and anode active material production

Activity data collection for cathode and anode (active material) production shall be done according to Table 4, following the data collection requirements according to section 6.2. Activity data shall be provided both per kg of the main output (product) of the modelled process and per functional unit. If the cathode active material production (e.g., NMC622) is done in a different plant than the cathode production, also the active material (AM) production shall be modelled according to Table 4, using a corresponding subset of inputs. If precursor materials are used in solution state, the specific concentration shall be provided. Direct carbon dioxide emissions from e.g., calcination step shall be considered. Inputs for by-product processing and purification shall be considered until the plant gate; allocation may be done in this case according to section 7.2.

Table 4. Generic data collection template for cathode and anode active material production

Component	Specification	Unit	Raw activity data per kg product (before CFF)	Alloc. activity data per kg product (after CFF applic.)	Alloc. activity data per FU (after CFF applic.)	UUID	Dataset name	Dataset Location	Dataset type	Priority process	-1 ad-justed to	TeR	TiR	GeR	Data source, collection method(s) and timespan (activity data)	Data collection date	Documentation for verification	Comments
Inputs																		
CAM Precursor	Cobalt sulphate ($CoSO_4$ x $7H_2O$), primary, provider y, country b	kg								y					e.g., total purchases from specific provider in 12 month, divided by cell output	2022	*indicate documents provided for verification*	
	Cobalt sulphate ($CoSO_4$ x $7H_2O$), primary, provider X, country a	kg								y					e.g., total purchases from specific provider in 12 month, divided by cell output	2022		
	Cobalt sulphate ($CoSO_4$ x $7H_2O$), secondary, provider X, country b	kg								y					e.g., total purchases from specific provider in 12 month, divided by cell output	2022		
	..									..								
CAM Precursor	Nickel sulphate ($NiSO_4$ x $7H_2O$), primary, provider X, country a	kg								y								
	Nickel sulphate ($NiSO_4$ x $7H_2O$), secondary, provider z, country c	kg								y								
	..									..								
CAM Precursor	Manganese sulphate ($MnSO_4$ x $7H_2O$), primary, provider .. , country ..	kg								y								
	Manganese sulphate ($MnSO_4$ x $7H_2O$), primary, provider .. , country ..	kg								y								
	..									..								
CAM Precursor	Lithium carbonate (Li_2CO_3), primary, from brine, provider .. , country ..	kg								y								
	Lithium carbonate (Li_2CO_3), primary, from brine, provider .. , country ..	kg								y								
	Lithium carbonate (Li_2CO_3), primary, from spodumene, provider .. , country ..	kg								y								
	Lithium hydroxide (LiOH*H2O), primary, from spodumene, provider .. , country ..	kg								y								
	..									..								
Additives	Carbon black, provider .. , country ..	kg								n								
	Nanocarbon, .. , ..	kg								y								
	Titanium dioxide, .. , ..	kg								n								
	other metal oxides, .., ..	kg								n								
	..																	
Auxiliaries	Water									n								
	Nitrogen, .., ..									n								
	inert gases, .., ..									n								
	..																	
Chemicals	Sodium hydroxide (NaOH), .., ..	kg								n								
	Sodium bicarbonate (Na_2CO_3), .., ..	kg								n								
	Ammonia solution (NH_4OH), .., ..	kg								n								
	..									..								

Component	Specification	Unit	Raw activity data per kg product (before CFF)	Alloc. activity data per kg product (after CFF applic.)	Alloc. activity data per FU (after CFF applic.)	UUID	Dataset name	Dataset Location	Dataset type	Priority process	-1 ad-justed to	TeR	TiR	GeR	Data source, collection method(s) and timespan (activity data)	Data collection date	Documentation for verification	Comments
Inputs																		
Electricity	Grid electricity, medium voltage	kWh								n					e.g., electricity bills, as from provider			
	PV electricity, on-site generation	kWh								n					total PV Generation measured by installation minus electricity injected into the grid (according to electricity bills)			
	..	..								..								
Thermal energy	e.g., steam, heat externally purchased	MJ								n								
	..	..								..								
Fuels	e.g., natural gas for on-site heat generation	MJ								n								
	..	..								..								
Transport	Lorry transport, international									n					Transport distances estimated based on location of manufacturing plant and country of origin of the material		calculation of transport distances per material provided in separate table	
	Train transport, international									n								
	Barge transport									n								
	Ship, transoceanic									n								
	Airplane									n								
Outputs																		
Intermediate product	***NMC[xxx] Cathode active material***					***Intermediate product; to Cell Manufacture***												
Direct emissions	CO_2 emission from calcination	kg				n/a	n/a		n/a	n/a	n/a	n/a	1	1	estimated based on stoichiometric considerations			
	CO_2 emission from fuel combustion	kg				n/a	n/a		n/a	n/a	n/a	n/a	1	1	estimated based on fuel input using EMEP/EEA fuel emission factors			

Source: JRC analysis.

A 2.2 Cell production

The cell production process may be divided into the three main steps: electrode manufacturing, the cell assembly, and the cell finishing, or even be further subdivided into the individual processes. Company-specific data may be collected for each process stage separately (or even on a higher level of disaggregation), or for the cell production as a whole, as long as all process steps are covered in the company-specific data collection. Data shall be provided both per kg of the main output (product) of the modelled process and per functional unit. A summary list of materials possibly needed for the cell production is given in Table 5.

In case activity data for material inputs (e.g., from a management system) are not available for a specific cell (only available aggregated for several cell products), a bill-of-material (BoM) may be used to compile the material inputs. The BoM shall include facility-specific yields, e.g., cuttings or individual scrap rates (including entire cells at the end of line testing).

For waste products that are recovered and re-used for the same purpose within the production premises (e.g., recovered and re-used solvents, re-used active materials), only the net input shall be accounted for. If recovered products are used for other purpose (e.g., solvents for cleaning, materials as filling material) within the premises, the corresponding amounts shall not be deducted from the inputs.

Energy consumption and auxiliaries

The energy consumption (but also auxiliaries, e.g., process water, compressed air, etc.) shall be based on an individual and detailed metering system to be able to split the energy / auxiliary consumption of the entire cell production into lines, products, and time periods. In case the energy / auxiliary consumption cannot directly be related to a specific product (e.g., several products produced in a facility, but consumption data is not always available per specific product), the data shall be collected as specific as possible, e.g., split up into energy /auxiliary consumption for electrode manufacturing, cell assembly, cell finishing, as well as climatization of clean / dry rooms. In case the energy / auxiliary consumption can be directly related to a specific process (e.g., electrode manufacturing), this data shall be used, in case the consumption data is only available for several cell products (e.g., individual meters for cell assembly lines, but only one meter for a dry room, in which several assembly lines produce different cells), the consumption data shall be split up by allocation: In case all cell products have the same geometry (pouch, cylindrical or prismatic) and the same size (e.g., cylindrical 18650), the allocation shall be done by number of cells, otherwise allocation shall be done by energy capacity (kWh).

Start-up period of new facilities

A start-up period for a new facility (new location, extension of capacity or exchange of entire production line) of maximum six months may be used to exclude non-representative energy consumption due to low utilization rates (e.g., load-independent energy consumers like dry room, climatization, etc.)

Table 5. Generic data collection template for cell production

Component	Specification	Unit	Raw activity data per kg product (before CFF)	Alloc. activity data per kg product (after CFF applic.)	Alloc. activity data per FU (after CFF applic.)	UUID	Dataset name	Dataset Location	Dataset type	Priority process	-1 ad-justed to	TeR	TiR	GeR	Data source, collection method(s) and timespan (activity data)	Data collection date	Documentation for verification	Comments
Inputs																		
Anode active material	Natural graphite, provider X, country a	kg								y					e.g., total purchases from specific provider in 12 month, divided by cell output	2022	*indicate documents provided for verification*	
	Natural graphite, provider Y, country b	kg								y					..	2022		
	Secondary graphite, provider Z, countr	kg								y					..	2022		
Anode active material additives	Silicon, .. , ..	..								y								
	Nanocarbon, .. , ..	..								y								
	..	..								..								
Cathode active	NMC622, primary, provider w, country (	kg								y								
	NMC622, primary, provider .., country ..									..					..			
Anode current collector	Copper foil rolling, provider u, country	kg								n								
	Copper, primary, provider u, country A	kg								n								TeR set to one due to combination with copper sheet production
	Copper, recycled, provider z, country D	kg								n								
	..	..								..								
Cathode current collector	Aluminium foil rolling	kg								y					sum of all primary and secondary aluminum input to electrode manufacturing line, monitoring, 12 m	2022	*indicate documents provided for verification*	
	Primary aluminium, Provider N, Countr	kg								y					...			
	Primary aluminium, Provider N, Countr	kg								y					...			
	Secondary aluminium, Provider O, Cou	kg								y					...			
	..	kg								..					...			
Separators	Polypropylene (PP), primary, Provider	kg								n					...			
	Polyethylene (PE), primary, Provider ..	kg								n					..	..		
	..									..					..	..		
Electrolyte solvents	Dimethyl carbonate, Provider .., Count	kg								n					..	..		
	Propylene carbonate, Provider .., Country ..									n					..	..		
	..									..					..	..		
Electrolyte salt	hydrogen fluoride, Provider .., Country	kg								n					..	..		
	phosphorous pentachloride, Provider .	kg								n					..	..		
	lithium hydroxide, Provider .., Country	kg								y					..	..		
	lime, Provider .., Country ..	kg								n					..	..		
	electricity for LiPF6 production	kg								y					..	..		
	..									..					..	..		

Component	Specification	Unit	Raw activity data per kg product (before CFF)	Alloc. activity data per kg product (after CFF applic.)	Alloc. activity data per FU (after CFF applic.)	UUID	Dataset name	Dataset Location	Dataset type	Priority process	-1 ad-justed to	TeR	TiR	GeR	Data source, collection method(s) and timespan (activity data)	Data collection date	Documentation for verification	Comments
Inputs																		
Housing	Primary aluminium, .. , ..	kg								y					..	..		
	Primary aluminium, .. , ..	kg								y					..	..		
	Secondary aluminium, .. , ..	kg								y					..	..		
	Aluminium sheet rolling, .. , ..	kg								n					..	..		
	Aluminium sheet deep drawing, .. , ..	kg								n					..	..		
	..	..								..					..	..		
	Steel, primary, low carbon,.. , ..	kg								y					..	..		
	Steel, secondary, ,.. , ..	kg								y					..	..		
	Steel sheet rolling, cold, .. , ..	kg								n					..	..		
	Steel sheet deep drawing, .. , ..	kg								n					..	..		
	..	..								..					..	..		
	Polypropylene (PP), primary, .. , ..	kg								n					..	..		
	Polypropylene (PP), secondary, .. , ..	kg								n					..	..		
	..									..								
Lids	Aluminium strips, .. , ..	kg								y								
	..	..								..								
Solvents	N-Methyl-2-pyrrolidone (NMP), .. , ..	kg								n								
	Water	..								n								
	..	..								..								
Auxiliaries	e.g., solvents, glues , .. , ..	kg								n								
	..	..								..								
Electricity	Grid electricity, medium voltage	kWh					residual grid mix, country ..			n					e.g., electricity bills, as from provider			
	PV electricity, on-site generation	kWh								n					e.g., total PV Generation measured by installation minus electricity injected into the grid (acc. to electricity bills)			
	..	..								..					..			
Thermal energy	e.g., steam, heat externally purchased	MJ								n								
	..									..								
Fuels	e.g., natural gas for on-site heat genera	MJ								n								
	..									..								
Others	..									..								
	..									..								
Outputs																		
Intermediate product	***Battery cells***						***to Pack Manufacture***											
Direct emissions	N-Methyl-2-pyrrolidone (NMP)	kg				n/a	n/a		n/a	n/a	n/a	n/a			..			
	CO_2 emission from fuel combustion	kg				n/a	n/a		n/a	n/a	n/a	n/a			e.g., estimated based on fuel input using EMEP/EEA fuel emission factors			
Wastes	Waste plastics, to landfill	kg								n					e.g., estimated based on delta between input and plastic content of battery; landfill fraction acc. to CFF default values			
	Waste plastics, to incineration	kg								n					..			
	Mixed residual waste, to landfill	kg								n					..			
	Mixed residual waste, to incineration	kg								n					..			
	Aluminium scrap, to recycling	kg								n					..			
	Copper scrap, to recycling	kg								n					..			
	Steel scrap, to recycling	kg								n					..			
	..	..								..								

Source: JRC analysis.

A 2.3 Battery assembly

Battery assembly covers the assembly of the battery module and the assembly of the battery itself. For both processes (or assembly steps), company-specific data shall be collected. Activity data for module and battery assembly shall be collected separately if they take place at different companies or locations. Activity data shall be provided both per kg of the main output (product) of the modelled process and per functional unit. Table 6 provides a summary list of materials possibly needed for the battery assembly step.

For batteries that provide additional functions to the vehicle, allocation may apply (see Section 7.2)

Table 6. Generic data collection template for battery assembly

Component	Specification	Unit	Raw activity data per kg product (before CFF)	Alloc. activity data per kg product (after CFF applic.)	Alloc. activity data per FU (after CFF applic.)	UUID	Dataset name	Dataset Location	Dataset type	Priority process	-1 ad-justed to	TeR	TiR	GeR	Data source, collection method(s) and timespan (activity data)	Data collection date	Documentation for verification	Comments
Inputs																		
Interm. product	***Battery cells***						***from Cell Manufacture***											
Pack housing	Primary aluminium, provider .. , country ..	kg								y					...			
	Primary aluminium, provider .. , country ..	kg								y					...			
	Secondary aluminium, provider .. , country ..	kg								y					...			
	Aluminium sheet rolling, .. , ..	kg								n								
	Aluminium sheet deep drawing, .. , ..	kg								n								
	..	..								..								
	Steel, primary, low carbon, provider .. , country ..	kg								y								
	Steel, secondary, provider .. , country ..	kg								y								
	Steel sheet rolling, cold, .. , ..	kg								n								
	Steel sheet deep drawing, .. , ..	kg								n								
	..	..								..								
	Polypropylene (PP), primary, provider .. , country ..	kg								n								
	Polypropylene (PP), secondary, provider .. , country ..	kg								n								
	Polypropylene (PP), injectionmoulding, .. , country ..	kg								n								
	..	..								..								
	Powder coating, .. , ..	..								n								
	..	..								..								
Cables, busbars, interconnectors	Copper (cables), .. , ..	kg								y								
	PVC (insulation), .. , ..	kg								n								
	Aluminium, primary [busbars], .. , ..	kg								y								
	Aluminium, secondary [busbars], .. , ..	kg								y								
	..	..								..								
Cooling system	Stainless steel [pipes], primary, provider .., country ..	kg								y								
	Stainless steel [pipes] , secondary, provider .., country ..	kg								y								
	Stainless steel shaping [pipes], provider .., country ..	kg								n								
	Steel , .., [pumps], .. , ..	kg								y								
	Copper , .., [pumps], .. , ..	kg								y								
	... , .. , [pumps], .. , ..	..								..								
	..	..								..								
	Ethylene glycol, .., ..	kg								n								
	..	..								..								
Electronics	Populated printed wiring board, power system, provider .., country ..	kg								n								
	Populated printed wiring board, logic circuits, provider .., country ..	kg								n								
	Connector, .. , ..	kg								n								
	..	..								..								

Component	Specification	Unit	Raw activity data per kg product (before CFF)	Alloc. activity data per kg product (after CFF applic.)	Alloc. activity data per FU (after CFF applic.)	UUID	Dataset name	Dataset Location	Dataset type	Priority process	-1 adjusted to	TeR	TiR	GeR	Data source, collection method(s) and timespan (activity data)	Data collection date	Documentation for verification	Comments
Inputs																		
Interm. product	***Battery cells***						***from Cell Manufacture***											
Other	Isolators (e.g., ceramics), .. , ..	kg								n								
	Insulation, .. , ..	kg								n								
	..	..								..								
	..	..								..								
Auxiliaries	e.g., solvents, glues	kg								n								
	..	..								..								
Electricity	Grid electricity, medium voltage	kWh								n					e.g., electricity bills, as from provider			
	PV electricity, on-site generation	kWh								n					total PV Generation measured by installation minus electricity injected into the grid (according to electricity bills)			
	..	..								..								
Thermal energy	e.g., steam, heat externally purchased	MJ								n								
	..	..								..								
Fuels	e.g., natural gas for on-site heat generation	MJ								n								
	..	..								..								
Outputs																		
Final product	***Battery pack***	***kg***																
Direct emissions	GHG emission from fuel combustion, light fuel oil	kg CO_2eq				n/a	n/a		n/a	n/a	n/a	n/a	1	1	estimated based on fuel input using EMEP/EEA fuel emission factors			
	GHG emission from fuel combustion, natural gas	kg CO_2eq				n/a	n/a		n/a	n/a	n/a	n/a	1	1	estimated based on fuel input using EMEP/EEA fuel emission factors			

Source: JRC analysis.

Annex 3. Default battery cell recycling process

Table 7 and Table 8 summarises the default activity data of the default battery cell recycling process.

Table 7. Default recycling model for battery cell recycling, pyrometallurgical treatment

Component	**Unit**	**Default value**	**Specification / dataset**	
Input				
EoL battery cells	kg	1.00	From disassembly	
Electricity	kWh	1.00	Residual electricity mix	
Process heat	MJ	2.288	Thermal energy from natural gas (90%)	
Process heat	MJ	0.237	Thermal energy from diesel fuel	
Limestone washed	kg	0.136	Lime production, technology mix	
Silica sand	kg	0.119	Silica sand, production mix	
Quicklime (CAO)	kg	0.085	Quicklime production, technology mix	
Carbon black	kg	0.001	Carbon black production, technology mix	
Outputs				
Metal alloy	kg	0.576	To hydrometallurgical treatment	May be adjusted according to specific battery cell composition (mass of cells fed to treatment - mass of alloy - mass of oxidised components accounted for in the direct CO2 emisisons)
Slag	kg	0.712	Landfill of inert slag	May be adjusted according to specific battery cell composition (mass of cobalt, copper, nickel, iron / steel, manganese; accounted for as metals, not as salts)
Emissions	Kg CO2eq	1.194	Direct process emissions (all greenhouse gases)	May be adjusted according to specific battery cell composition (estimated based on stoichiometric calculation, assuming complete oxidation of all organic / carbonaceous compounds during pyrometallurgy)

Source: JRC analysis.

Table 8. Default recycling model for battery cell recycling, hydrometallurgical treatment.

Component	**Unit**	**Default value**	**Specification / dataset**	
Input				
Metal alloy	kg	0.576	Default value, if output from previous stage is different, all process inputs below shall be adjusted correspondingly	
Electricity	kWh	0.025	Residual electricity mix	
Process heat	MJ	1.842	Thermal energy from natural gas (90%)	
Process heat	MJ	0.041	Thermal energy from light fuel oil	
Ammonium nitrate	kg	0.024	HCl production, technology mix	
Hydrochloric acid (100%)	kg	0.010	Hydrogen peroxide production, technology mix	
Hydrogen peroxide (100%)	kg	0.301	production, technology mix	
Soda (sodium carbonate)	kg	0.016	Soda production, technology mix	
Sodium hydroxide (100%; caustic soda)	kg	0.454	Sodium hydroxide production, technology mix	
Sulphuric acid aq. (96%)	kg	0.876	Sulphuric acid production, technology mix	
Water (tap water)	m3	0.003		
Outputs				
Recovered metals	kg		e.g., Aluminium, Copper, steel, stainless steel, ..	Credit for each specific metal according to its content in the battery cell and parameters R_{coll}, A, R_{rec} and 'Qsout/Qp' of the CFF
Recovered metal salts	kg		e.g., Cobalt sulphate, Nickel sulphate ..	Credit for each specific metal salt according to its stoichiometric content in the battery cell and parameters

				R_{coll},A, $R_{rec,}$ and 'Qsout/Qp' of the CFF
Wastewater	m3	0.003	Wastewater treatment, average	

Source: JRC analysis.

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