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ARTICLE

The Legal Transition Towards a More Circular Battery Value Chain: A Critical Analysis of the Batteries Regulation

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Abstract
Batteries are identified as a key product value chain, not only for the transition to climate neutrality but also for the European Union's (EU) transition towards a circular economy (CE). Therefore, the EU has the ambition to create an ecosystem for sustainable batteries that follows a CE approach. As part of this effort, the EU has reviewed and revised the legislation governing the life cycle of batteries: EU chemicals, product and waste legislation. A recent example is the adoption of the Batteries Regulation, which is the first comprehensive legal framework focusing on the entire life cycle of a specific product. The Regulation removes many barriers and introduces incentives to support the transition towards a more circular battery value chain, as identified in this article through both literature and stakeholder interviews in the Netherlands. Compared to the Batteries Directive, the Batteries Regulation appears to better align with and contribute more effectively to CE objectives. Yet, this article also identifies some remaining challenges and suggestions for improvement. Close attention should be paid to the implementation of the Batteries Regulation and its encouragement of higher value retention strategies, as well as to the interaction within the legal framework on batteries as a whole to prevent adverse effects and to exploit synergies in pursuance of CE objectives.

Keywords: Circular economy (CE); Batteries; EU Batteries Regulation; EU Batteries Directive

1. Introduction

The European Union (EU) is transitioning towards a circular economy (CE), which can be described as an economy 'where the value of products, materials and resources is maintained in the economy for as long as possible, and the generation of waste is minimized'.[1] The CE transition forms part of the EU Green Deal, in which the CE is described as a means to contribute to achieving the EU's sustainability goals and climate neutrality by 2050.[2] For both objectives, batteries are considered a key product

[1] European Commission, 'Closing the Loop: An EU Action Plan for the Circular Economy', 2 Dec. 2015, COM(2015) 614 final, p. 2.

[2] Ibid.; European Commission, 'The European Green Deal', 11 Dec. 2019, COM(2019) 640 final, pp. 2, 7–9; for climate neutrality see also European Commission, 'A Clean Planet for All: A European Strategic

value chain.[3] They support low-emissions electro-mobility, contribute to stabilizing the power grid,[4] and are widely used in industrial applications as well as in electrical and electronic equipment.[5] The demand for batteries, especially for the predominant 'lithium-ion' chemistry used in electric vehicles,[6] will increase rapidly in the coming years.[7] Recognized as a strategic value chain, the EU aims to create an ecosystem for sustainable batteries, which includes responsible material sourcing, the lowest carbon footprint possible, and a CE approach.[8] The latter is considered to enable the battery value chain to become resource-efficient and to prevent the loss of potential value and secondary materials.[9] This approach addresses the supply of rare and critical raw materials typically used in batteries and contributes to reducing their environmental impact.[10] The transition towards a CE for batteries can be considered a prerequisite for the clean energy transition and climate neutrality.[11]

To realize an ecosystem for sustainable and circular batteries, the EU has taken steps to review and revise the legislation governing the life cycle of batteries, including EU chemicals, product and waste legislation. Since the introduction of the first Circular Economy Action Plan,[12] the most notable development is the recently adopted Regulation (EU) 2023/1542 concerning Batteries and Waste Batteries

Long-Term Vision for a Prosperous, Modern, Competitive and Climate Neutral Economy', 28 Nov. 2018, COM(2018) 773 final.

3 European Commission, 'A New Circular Economy Action Plan: For a Cleaner and More Competitive Europe', 11 Mar. 2020, COM(2020) 98 final, pp. 7–8.

4 European Commission, 'Report on the Implementation of the Strategic Action Plan on Batteries: Building a Strategic Battery Value Chain in Europe', 9 Apr. 2019, COM(2019) 176 final, p. 1; see also European Commission, n. 3 above.

5 See, e.g., H. Friege et al., 'The New European Database for Chemicals of Concern: How Useful is SCIP for Waste Management?' (2021) 21 *Sustainable Chemistry and Pharmacy*, article 100430, p. 5.

6 European Commission, 'Europe on the Move: Sustainable Mobility for Europe: Safe, Connected and Clean', 17 May 2018, COM(2018) 293 final, Annex II.

7 European Commission, n. 4 above, pp. 1–2; European Commission, 'Working Document on the Evaluation of the Directive 2006/66/EC on Batteries and Accumulators and Waste Batteries and Accumulators and repealing Directive 91/157/EEC', 9 Apr. 2019, SWD(2019) 1300 final, p. 31; Y.A. Alamerew & D. Brissaud, 'Modelling Reverse Supply Chain through System Dynamics for Realizing the Transition towards the Circular Economy: A Case Study on Electric Vehicle Batteries' (2020) 254 *Journal of Cleaner Production*, article 120025, p. 3.

8 European Commission, n. 4 above, pp. 6–7. See also European Commission, n. 6 above, pp. 1–2.

9 J. Ahuja, L. Dawson & R. Lee. 'A Circular Economy for Electric Vehicles: Driving the Change' (2020) 12(3) *Journal of Property, Planning and Environmental Law*, pp. 235–50, at 235–6.

10 Ibid., pp. 240–1; L. Albertsen et al., 'Circular Business Models for Electric Vehicle Lithium-Ion Batteries: An Analysis of Current Practices of Vehicle Manufacturers and Policies in the EU' (2021) 172 *Resources, Conservation and Recycling*, p. 2; N. Hill et al., *Circular Economy Perspectives for the Management of Batteries Used in Electric Vehicles* (Publications Office of the EU, 2019), p. 121; E. Kastanaki & A. Giannis, 'Dynamic Estimation of End-Of-Life Electric Vehicle Batteries in the EU-27 Considering Reuse, Remanufacturing and Recycling Options' (2023) 393 *Journal of Cleaner Production*, article 136349, p. 1.

11 European Commission, 'Evaluation of Directive (EC) 2000/53 of 18 Sept. 2000 on End-of-Life Vehicles', 15 Mar. 2021, SWD(2021) 60 final, p. 55; C. Hagelüken & D. Goldmann, 'Recycling and Circular Economy: Towards a Closed Loop for Metals in Emerging Clean Technologies' (2022) 35(3) *Mineral Economics*, pp. 539–62, at 552.

12 European Commission, n. 1 above.

(Batteries Regulation).[13] The Regulation aims to make batteries sustainable, safe, and circular throughout their entire life cycle. It is the first comprehensive legal framework to focus on the entire life cycle of a specific product.[14] The Batteries Regulation replaces Directive 2006/66/EC on Batteries and Accumulators and Waste Batteries and Accumulators (Batteries Directive);[15] it aims to eliminate barriers, while leveraging untapped opportunities for the transition to a more sustainable and circular battery chain.

This research aims to identify legal barriers to and incentives for this transition, and examines whether they have been adequately addressed by the Barriers Regulation. The Netherlands serves as a case study for this research. Additionally, a subsequent analysis focuses on any remaining challenges, particularly in relation to the European Commission's new approach of regulating the entire life cycle of a specific product.

To facilitate an in-depth legal analysis, empirical legal research was conducted through semi-structured interviews, alongside legal doctrinal desk research. The aim of the empirical research was to identify potential barriers and incentives, as well as to validate those identified in the desk research. The Netherlands was selected as a focus for examining the implementation of this legal framework. Currently, the Netherlands ranks as one of the lower-performing EU Member States in terms of the collection percentage of (portable) batteries, while also being among the average to best performers in recycling efficiencies for batteries.[16] This status makes it an interesting case to examine both the successful implementation of battery legislation and areas for improvement. In September and October 2023, 19 semi-structured interviews were conducted with 22 stakeholders representing the entire battery value chain in the Netherlands (see Table 1). Stakeholders were selected based on purposive sampling and snowball sampling.[17] Interviewed stakeholders were asked about their own experiences with the transition towards a more circular battery value chain, the barriers they encountered, and the solutions or incentives they would find desirable within the legal framework governing the life cycle of batteries.[18]

This article is structured as follows. Section 2 discusses the barriers and (lack of) incentives for a more circular battery value chain, paying specific attention to the recently adopted Batteries Regulation. Section 3 analyzes the relation between the Batteries Regulation and the CE and presents general observations regarding the approach taken in the Batteries Regulation. Section 4 concludes.

[13] Regulation (EU) 2023/1542 concerning Batteries and Waste Batteries, amending Directive 2008/98/EC and Regulation (EU) 2019/1020 and repealing Directive 2006/66/EC [2023] OJ L 191/1 (Batteries Regulation).

[14] See, *inter alia*, Batteries Regulation, ibid., Art. 1(3); European Commission, 'Proposal for a Regulation of the European Parliament and of the Council concerning Batteries and Waste Batteries, repealing Directive 2006/66/EC and amending Regulation (EU) No 2019/1020', 10 Dec. 2020, COM(2020) 798 final, p. 1.

[15] Directive 2006/66/EC on Batteries and Accumulators and Waste Batteries and Accumulators and repealing Directive 91/157/EEC [2006] OJ L 266/1 (Batteries Directive).

[16] Eurostat, 'Waste Statistics: Recycling of Batteries and Accumulators', available at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Waste_statistics_-_recycling_of_batteries_and_accumulators.

[17] L. Webley, 'Qualitative Approaches to Empirical Legal Research' in P. Cane & H. Kritzer (eds), *Oxford Handbook of Empirical Legal Research* (Oxford University Press, 2010).

[18] H.R. Boeije, *Analysis in Qualitative Research* (SAGE, 2009).

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Table 1. Overview of Interviewed Stakeholders

Category	Number of Stakeholders
Manufacturers, distributors and importers of batteries and battery systems	9
Deployment of batteries and battery systems in appliances and vehicles	2
Repairers, remanufacturers and (preparation for) repurposing and re-use operators	4
Battery waste management operators	2
Producer responsibility organizations and notified bodies	3
Governmental organization officials	2

2. Legal Barriers and Incentives for the Transition towards a More Circular Battery Value Chain

Both the literature and the interviews identified barriers to and incentives for the transition to a more circular battery value chain, including those relating to the legal framework governing the battery life cycle. The most notable development in this regard is the recent adoption of the Batteries Regulation,[19] which replaced the Batteries Directive[20] on 18 August 2025. The Regulation entered into force on 17 August 2023 and became applicable on 18 February 2024, with the exception of several provisions, the application of which will begin at various staggered dates up to 2033.[21] It should be noted that most of the literature predates the coming into force of the Batteries Regulation, which means that many referenced barriers and incentives were related to the Batteries Directive. Nevertheless, some of the literature referred to potential barriers and incentives based on the proposal for the Batteries Regulation.[22] These have been included where the text of the proposal corresponds to the adopted text of the Batteries Regulation.

2.1. EU Chemicals Legislation

The chemical substances used in batteries are regulated by both general and sector-specific EU chemicals legislation. In general, chemicals used in batteries are covered by the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Regulation.[23] In addition, the Batteries Directive regulated the use of certain chemical

[19] N. 13 above.
[20] N. 15 above.
[21] Batteries Regulation, n. 13 above, Art. 96.
[22] See, *inter alia*, L. Dawson, J. Ahuja & R. Lee, 'Steering Extended Producer Responsibility for Electric Vehicle Batteries' (2021) 23(2) *Environmental Law Review*, pp. 128–43; R. Barkhausen et al., 'Analysing Policy Change Towards the Circular Economy at the Example of EU Battery Legislation' (2023) 186 *Renewable and Sustainable Energy Reviews*, article 113665; J. Malinauskaite, L. Anguilano & X. Schmidt Rivera, 'Circular Waste Management of Electric Vehicle Batteries: Legal and Technical Perspectives from the EU and the UK Post Brexit' (2021) 10 *International Journal of Thermofluids*, article 100078.
[23] Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), Establishing a European Chemicals Agency, amending Directive 1999/45/EC

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substances in batteries by restricting the use of mercury and cadmium above a certain percentage by weight. It also required labelling when cadmium, mercury, and lead were present above certain thresholds.[24]

Restrictions on hazardous substances under the Batteries Directive

The provisions in the Batteries Directive have been successful in reducing the amount of mercury and cadmium in batteries.[25] At the same time, the Directive was criticized for inadequately addressing the management of risks posed by these substances. Although the Directive did contain a provision aimed at incentivizing the use of smaller quantities of these dangerous substances or the use of less polluting substances, its evaluation indicated that this provision led to ambiguity in its interpretation.[26] As these harmful substances continue to be used in batteries,[27] it has been suggested that the focus should shift towards preventing the use of hazardous elements altogether.[28]

Moreover, it was argued that the Batteries Directive was unable to address concerns related to the use of new substances in batteries. It failed to specify the criteria for identifying such substances, as well as potential management measures.[29] These critiques are especially relevant considering the many recent developments in battery chemistries involving other (hazardous) substances, as became evident in multiple interviews with battery manufacturers. As a result, the evaluation of the Directive stated that stakeholders would prefer to manage and regulate all chemicals used in batteries under REACH, rather than a sector-specific legal act.[30] REACH already regulates the use of cadmium, mercury, and lead in general, as well as the use of other chemicals in batteries.[31]

Regulating hazardous substances under the Batteries Regulation

Similar to the Batteries Directive, the Batteries Regulation contains restrictions on the use of mercury and cadmium in batteries. It also introduces a restriction on the use of lead, all under certain conditions.[32] In other words, although the Recitals of the Batteries Regulation state that the use of hazardous substances in batteries should

and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/ EEC, 93/67/EEC, 93/105/EC and 2000/21/EC [2006] OJ L 396/1.

24 Batteries Directive, n. 15 above, Art. 4.

25 European Commission, n. 7 above, p. 41.

26 Batteries Directive, n. 15 above, Arts 5, 9; European Commission, n. 7 above, p. 41.

27 European Commission, n. 7 above, pp. 60–1.

28 V. Anand et al., 'A Study of Regulatory and Technological Considerations of Waste Management of Electric Vehicle Batteries' (2023) 3(1) *Indian Journal of Science and Research*, pp. 29–35, at 31.

29 European Commission, n. 7 above, p. 41; European Commission, 'Report on the Implementation and the Impact on the Environment and the Functioning of the Internal Market of Directive 2006/66/EC of 6 September 2006 on Batteries and Accumulators and Waste Batteries and Accumulators and repealing Directive 91/157/EEC', COM(2019) 166, p. 3.

30 European Commission, n. 7 above, pp. 61, 64.

31 Nevertheless, it appears that the REACH Regulation does not duplicate or contradict the Batteries Directive or the Batteries Regulation; see ibid., pp. 21, 60.

32 Batteries Regulation, n. 13 above, Art. 6 and Annex I.

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primarily be restricted at source,[33] the use of these chemicals in batteries is still allowed under the Regulation.

Nevertheless, the Batteries Regulation also introduces an additional restriction by implementing measures to monitor and control unacceptable risks to human health or the environment arising from the use of substances in batteries, as well as their use in manufacturing or during subsequent life-cycle stages.[34] In doing so, the Regulation appears to address the criticism of the inability of the Batteries Directive to address concerns related to the use of new substances in batteries. It could be argued, therefore, that this addition may also partly address the underlying argument that REACH would be more suitable for regulating all substances in batteries.[35]

Moreover, the Batteries Regulation also shows improvement regarding the availability of information on substances in batteries and transparency across the value chain.[36] This is achieved through more extensive labelling requirements, as well as the inclusion of information on hazardous substances in 'battery passports' (see Section 2.2).[37] This information can facilitate the recycling of waste batteries,[38] and support the subsequent compliance with REACH requirements, which apply as soon as the recycled materials that have been recovered from waste batteries cease to be waste.[39]

2.2. EU Product Legislation

The choices made at the design stage of batteries influence not only the use stage, such as the number of charging cycles, but also have an impact on resource extraction, as well as repair and end-of-life (EoL) treatment options.[40] However, both the literature and the interviews indicated that, currently, the design of batteries (particularly lithium-ion batteries) regularly hampers the repair, remanufacturing, re-use, repurposing, and recycling of batteries or their components.[41] In particular, it was frequently mentioned as an obstacle that batteries are difficult to remove or are not designed for easy disassembly.[42] All in all, as decisions made at the product stage affect

[33] Ibid., Recital 21.
[34] Batteries Directive, n. 15 above, Arts 6(2), 6(4), 89; Recital 24.
[35] Batteries Regulation, n. 13 above, Recital 21.
[36] See also Hill et al., n. 10 above, pp. 129–30.
[37] Batteries Regulation, n. 13 above, Art. 13(1); Annex VI, Art. 77(2); Annex XIII; see also ibid., Recitals 44, 123.
[38] See also Hill et al., n. 10 above, p. 164.
[39] Ibid., pp. 129–30.
[40] See, e.g., A. Danthinne & M. Picard, 'Assessing the Compatibility of Vehicle Electrification with the EU's Circular Economy Objective' (2022) 31(6) *European Energy and Environmental Law Review*, pp. 394–404, at 403.
[41] A. Farmer & E. Watkins, *Managing Waste Batteries from Electric Vehicles: The Case of the European Union and Japan* (Institute for European Environmental Policy, 2023), pp. 35–6.
[42] D.L. Thompson et al., 'The Importance of Design in Lithium Ion Battery Recycling: A Critical Review' (2020) 22 *Green Chemistry*, pp. 7585–603, at 7589; P. Rönkkö et al., 'The Circular Economy of Electric Vehicle Batteries: A Finnish Case Study' (2024) 44 *Environment Systems and Decisions*, pp. 100–13, at 104; G. Harper et al., 'Recycling Lithium-Ion Batteries from Electric Vehicles' (2019) 575(7781) *Nature*,

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achieving CE objectives for batteries, an increased focus on EoL or CE aspects in their design could contribute to realizing a circular battery sector.[43]

Looking more closely at the situation in practice, some interviewed manufacturers said that they are applying strategies that could be considered in line with design for EoL or CE approaches, and that some cooperation already occurs across the value chain to this end. Examples include focusing on lifetime extension, modularity, disassembly, and recyclability. However, the interviewees clarified that their main motivation for adopting these strategies were often related to serviceability or costs, rather than the CE transition.

Several of the interviewed manufacturers confirmed that CE objectives are not yet considered in their battery design. In particular, start-ups and scale-ups stated that, although they have the ambition to apply secondary materials or design for EoL, their priorities are currently focused on other aspects, such as battery performance or securing a competitive market position. Other reasons include a lack of supply of secondary materials and components, performance-related uncertainties, and the fact that they are not yet confronted with the EoL stage because of the long lifetime of their product. Moreover, the manufacturers stated that prioritizing design for circularity, such as through design for disassembly or the use of recycled content, can result in potentially conflicting objectives regarding safety, technical performance or environmental impact.

Product design requirements prior to the Batteries Regulation

Many legal instruments currently contain provisions related to the product stage of either batteries or the appliances in which batteries are used, such as electric vehicles (EV) or electrical and electronic equipment. The Batteries Directive already required batteries in appliances to be readily removable.[44] Similarly, both Directive 2000/53/EC on End-of Life Vehicles (ELV Directive)[45] and Directive 2012/19/EU on Waste Electrical and Electronic Equipment (WEEE Directive)[46] require the dismantling of components (i.e., batteries) to be taken into account in product design, respectively promoting design in view of facilitating the dismantling of components.[47]

However, as previously mentioned, batteries are still often difficult to remove or are not designed for easy disassembly or dismantling. One reason for this is the vagueness of the removability criteria in the Batteries Directive, particularly regarding when

pp. 75–86, at 84; J. Ahlers et al., 'Analysis of Extended Producer Responsibility Schemes', Adelphi Consult GmbH, June 2021, p. 78.

43 Malinauskaite, Anguilano & Schmidt Rivera, n. 22 above, p. 7; B.M. Sopha, D.M. Purnamasari & S. Ma'mun, 'Barriers and Enablers of Circular Economy Implementation for Electric-Vehicle Batteries: From Systematic Literature Review to Conceptual Framework' (2022) 14(10) *Sustainability*, article 6359, p. 19; P. Eleftheriadis et al., 'Second Life Batteries: Current Regulatory Framework, Evaluation Methods, and Economic Assessment', IEEE International Conference on Environment and Electrical Engineering, 2022, pp. 1–6, at 3.

44 Batteries Directive, n. 15 above, Arts 1, 4, 11, 21.

45 [2000] OJ L 269/34 (ELV Directive).

46 [2012] OJ L 197/38 (recast) (WEEE Directive).

47 ELV Directive, n. 45 above, Art. 4; WEEE Directive, n. 46 above, Art. 4.

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removal must take place. The criteria also lacked sufficiently detailed exemptions, leading to different interpretations, the creation of loopholes, and complications in implementation. In turn, this has a negative impact on collection and recycling objectives. In addition, the disassembly of the battery itself was not addressed. Another shortcoming concerns the absence of regulating the replaceability of batteries, which could lead to a situation where the entire appliance must be replaced instead of just the battery.[48]

More generally, the Batteries Directive has been criticized for lacking (sufficiently detailed) battery design requirements, including those related to durability, recycled content, (minimum) performance, disassembly, recyclability, environmental quality, and environmental performance.[49] The respective labelling requirements of the Directive have also been criticized as being inadequate in contributing to EoL operations and circularity practices.[50]

The extension of existing product requirements in the Batteries Regulation

The Batteries Regulation maintains and expands product requirements that were already in existence under the Batteries Directive and introduces new ones.[51] These product requirements aim to ensure that batteries are designed and manufactured to optimize battery performance, durability, and safety, while minimizing their environmental footprint.[52]

The Batteries Regulation still contains requirements on the removability of batteries as well as on labelling and information. With regard to removability, it becomes clear that it now also addresses battery replaceability.[53] The new requirement clarifies what qualifies as removable and replaceable, specifies when removal must take place, requires the availability of spare parts, and formulates exemptions in more detail.[54] To further facilitate a harmonized application, guidelines have been published by the European Commission.[55] Many of the issues with the removability provision of the Batteries Directive thus seem to be addressed.

However, in contrast to the Directive's provision, the new removability and replaceability requirement remarkably applies only to portable and light means of transport (LMT) batteries. The Recitals in the Batteries Regulation state that starting, lighting, and ignition (SLI) and EV batteries, which are incorporated in motor vehicles,

[48] European Commission, n. 7 above, pp. 61, 42.

[49] Danthinne & Picard, n. 40 above, p. 403; European Commission, n. 7 above, pp. 41, 62–3; Hill et al., n. 10 above, p. 169; M. Cordella et al., *Investigating Alignment and Potential Synergies on Circular Economy Requirements between Sustainable Product Policy Instruments* (European Commission, 2018), p. 41.

[50] B. Faessler, 'Stationary, Second Use Battery Energy Storage Systems and Their Applications: A Research Review' (2021) 14(8) *Energies*, article 2335, p. 12.

[51] Batteries Regulation, n. 13 above, Art. 5; See also ibid., Recital 43.

[52] Ibid., Recital 19.

[53] Ibid., Arts 11, 95, 96.

[54] Ibid., Art. 11.

[55] Ibid., Art. 11(9); Commission Notice, 'Commission Guidelines to Facilitate the Harmonised Application of Provisions on the Removability and Replaceability of Portable Batteries and LMT Batteries in Regulation (EU) 2023/1542' [2025] OJ C/2025/214.

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should be removable and replaceable by independent professionals. At the same time, the Recitals state that it is appropriate to consider a revision of the ELV Directive to ensure this.[56] From the perspective of the Batteries Regulation, such a provision also could, or perhaps should, have been included in the Regulation. In its absence, the issue of the removability of industrial batteries still remains to be addressed.

Moreover, the removability and replaceability requirement in the Batteries Regulation addresses only to a very limited extent the design for disassembly of the battery itself, despite the fact that such requirements could facilitate reuse, repurposing, and recycling.[57] Only with regard to LMT batteries does the Regulation require that both batteries and individual battery cells are readily removable and replaceable by a professional.[58] In practice, this means that those batteries should be designed for disassembly. Surprisingly, this requirement was strongly rejected by two interviewed repairers. They argued that the requirement not only will lead to questions from original equipment manufacturers regarding accountability, but also that it is not useful, as these repairers have practically never experienced the need to replace an individual cell.

With a view to the labelling and information requirements, it appears that the previous requirements of the Batteries Directive have been extended. Except for the requirement to show the presence of mercury through a chemical symbol on the label of the battery,[59] all batteries will soon have to bear a label containing general information. This information includes their chemistry, the presence of hazardous substances other than mercury, cadmium or lead, and the presence of critical raw materials present in a concentration of more than 0.1% by weight.[60] An interviewed waste operator stressed that detailed labelling requirements, especially regarding battery chemistries, are particularly desirable as they aid in sorting and recycling. The Batteries Regulation requires the above-mentioned information to be provided through a QR code.[61] Additionally, it requires the provision of information on the state of health and expected lifetime of batteries.[62]

Altogether, the Batteries Regulation appears to address the criticism that the requirements under the Directive were insufficient, as it contains more extensive and detailed requirements for all batteries. These new requirements could help to inform stakeholders about the performance and quality of batteries and contribute to overcoming obstacles related to the diversity in battery design and chemistries. They also facilitate subsequent EoL management by providing more information about disassembly, dismantling, and recyclability.[63]

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[56] Batteries Regulation, n. 13 above, Recital 42.
[57] Farmer & Watkins, n. 41 above, p. 36.
[58] Batteries Regulation, n. 13 above, Art. 11(5); by contrast see ibid., Art. 11(1).
[59] Ibid., Art. 13(4), 13(1); Part A Annex VI.
[60] Ibid., Art. 13(1); Part A Annex VI.
[61] Ibid., Art. 13(6).
[62] Ibid., Art. 14 and Annex VII.
[63] See, *inter alia*, Rönkkö et al., n. 42 above, p. 104; Cordella et al., n. 49 above, p. 41; Faessler, n. 50 above, p. 12; F. Di Persio et al., *Information Gap Analysis for Decision Makers to Move EU Towards a Circular Economy for the Lithium-Ion Battery Value Chain* (Publications Office of the EU, 2020), p. 47;

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The introduction of new product requirements in the Batteries Regulation

The Batteries Regulation introduces several new product requirements related to the sustainability and safety of batteries. These include the introduction of a carbon footprint for EV, rechargeable industrial and LMT batteries; recycled content requirements for industrial, EV, LMT, and SLI batteries; performance and durability requirements for portable batteries of general use and rechargeable industrial, LMT, and EV batteries; and, lastly, safety requirements for stationary energy storage systems.[64] In the light of the CE transition, the mandatory use of recycled content is an especially important new requirement. According to the Recitals in the Batteries Regulation, the use of recovered materials would not only support the transition towards a CE but also lead to more resource-efficient use of these materials. This is especially relevant for substances that are scarce or classified as critical raw materials, particularly those for which recycled content targets have been set: cobalt, lead, nickel, and lithium.[65]

Several interviewees across the value chain were positive about the introduction of the recycled content requirement, arguing that it will contribute to creating a stable market for secondary materials. They also said that this development promotes the improvement of recycling facilities in the Netherlands. At the same time, various concerns were raised. A waste operator explained that manufacturers of cells and components depend on the supply of sufficient high-quality secondary materials, which are currently not always available. Battery manufacturers, in turn, stated that to comply with recycled content requirements, they rely on cell or component manufacturers, who are often located outside the EU. The manufacturers therefore expressed their concerns about the difficulty of monitoring compliance by cell and component manufacturers.

Some of the above-mentioned challenges are addressed in the Batteries Regulation. For example, the recycled content requirement progressively evolves from an information disclosure requirement to mandatory targets, taking into account the technical feasibility and the time needed to adapt supply and manufacturing processes.[66] In addition, the European Commission will further assess whether it is appropriate to revise these targets in line with the risk of supply shortages and developments in new battery chemistries.[67]

The Batteries Regulation also introduces due diligence obligations and a battery passport. Economic operators with a certain net turnover will have to fulfil due diligence obligations related to the sourcing, processing, and trading of certain (critical) raw materials, in order to prevent and reduce the negative environmental and social impacts of these materials and create a sustainable battery value chain.[68] Some

Alamerew & Brissaud, n. 7 above, p. 9; R. Lihammar et al., *The International Ecosystem for Accelerating the Transition to Safe-And-Sustainable-By-Design Materials, Products and Processes* (IRISS, 2023), p. 83.

64 Batteries Regulation, n. 13 above, Arts 7, 8, 9, 10, 12.

65 Ibid., Recitals 29, 30.

66 Ibid., Recital 30.

67 Ibid., Art. 8(5), 8(6); Recitals 31, 32.

68 Ibid., Arts 1(2), 3(42), 47–53; Annex X, Recitals 77–94. By now the European Commission has proposed, also as part of the 'Omnibus' simplification package, some changes in respect of obligations relating to battery due diligence policies. The Commission proposed (i) to postpone the application of

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interviewed manufacturers reported that their clients already inquire about due diligence information or sometimes even request a reduction in the use of certain (critical) raw materials, both based on sustainability objectives and corporate social responsibility regulations. Although the latter could offer some relief in this regard, the interviewees nevertheless questioned its effect, especially in view of information reliability and enforceability.

Furthermore, the Batteries Regulation requires industrial and EV batteries to be accompanied by a battery passport. This electronic record is accessible through a QR code and contains information on, among other things, material composition, carbon footprint, share of recycled and renewable content, and expected lifetime.[69] The battery passport aims to enhance transparency across the value chain and to provide essential information for all stakeholders.[70] The literature and interviews frequently noted that this development could indeed facilitate repair, second-life and recycling processes, and more generally enable circular business models.[71] For example, the battery passport will provide dismantling information along with details of the state of health and status of the battery for repairers and second-life operators.[72] Several interviewed stakeholders in the value chain revealed that this obligation corresponds partly with the information they are already collecting. However, others stated that complying with the battery passport requirements will be a major challenge for the industry, especially in view of the high administrative burden.

2.3. EU Waste Legislation

Batteries that are (intended to be) discarded become waste batteries. The Batteries Directive focused mainly on this stage of the battery life cycle, containing provisions on the separate collection and recycling of waste batteries, for which producers were responsible through extended producer responsibility (EPR).

these due diligence requirements; (ii) to extend the 'certain net turnover' from 40 million to 150 million euros, extending the exemption for obligations regarding battery due diligence policies; (iii) to publish reports on due diligence not annually but every three years. See European Commission, 'Proposal for a Regulation amending Regulation (EU) 2023/1542 as regards Obligations of Economic Operators concerning Battery Due Diligence Policies', 21 May 2025, COM(2025) 258 final; European Commission, 'Proposal for a Regulation amending Regulations (EU) 2016/679, (EU) 2016/1036, (EU) 2016/1037, (EU) 2017/1129, (EU) 2023/1542 and (EU) 2024/573 as regards the Extension of Certain Mitigating Measures Available for Small and Medium Sized Enterprises to Small Mid-Cap Enterprises and Further Simplification Measures', 23 May 2025, COM(2025) 501 final.

69 Batteries Regulation, n. 13 above, Art. 77 and Annex XIII.

70 Ibid., Art. 77, Recital 123.

71 A. Kampker et al., 'Identification of Challenges for Second-Life Battery Systems: A Literature Review' (2023) 14(4) *World Electric Vehicle Journal*, article 80, p. 4; Farmer & Watkins, n. 41 above, p. 36; K. Berger et al., 'Factors of Digital Product Passport Adoption to Enable Circular Information Flows Along the Battery Value Chain' (2023) 116 *Procedia CIRP*, pp. 528–33, at 532. See also, critically, V. Rizos & P. Urban, 'Barriers and Policy Challenges in Developing Circularity Approaches in the EU Battery Sector: An Assessment' (2024) 209 *Resources, Conservation & Recycling*, article 107800, pp. 4–5.

72 Batteries Regulation, n. 13 above, Art. 77(2) and Annex XIII.

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Management of waste batteries under the Batteries Directive

The evaluation of the Directive showed that it had a positive effect on the collection and recycling of batteries. However, it simultaneously criticized the provisions on collection and recycling for insufficiently reflecting CE and resource efficiency policies, as well as for not contributing enough to the objective of achieving a high level of material recovery.[73]

The Batteries Directive's collection target has proved to be insufficient for ensuring a high level of collection of waste batteries. Many Member States, including the Netherlands in recent years, have not met the collection target of 45% for all waste portable batteries, which means that the majority of waste portable batteries are not being collected.[74] Several factors could explain these low collection rates. The first is the difficulty in implementing the provisions on awareness raising and accessibility of collection points because of their lack of detail. Secondly, the limitation of the collection target only to portable batteries constitutes a challenge.[75] Thirdly, the inappropriate method for calculating the collection rate is a concern as this method, *inter alia*, does not take into account the varying lifetimes of batteries or exported batteries.[76] In the interviews, the latter was given as one of the main reasons for not meeting the collection target by the Dutch producer responsibility organization for portable batteries. Several interviewees suggested that a new calculation method based on 'available for collection' would be desirable.

Altogether, the issues with the provisions of the Directive on the collection of waste batteries not only have a negative effect on environmental protection but also on the achievement of other targets and objectives, such as material recovery. The lack of specific collection and reporting obligations for industrial batteries has been considered especially problematic.[77]

Furthermore, the provisions on recycling, particularly those on recycling efficiency, have been criticized. As the definition of recycling efficiency is linked to the recycling process and based on the average weight of waste batteries, meeting recycling targets has not been leading automatically to high levels of material recovery.[78] The fact that there are no specific targets for the recovery of other (critical or hazardous) materials, besides lead and cadmium, also has a negative impact.[79] In particular, the classification of lithium-ion batteries as 'other' batteries has not ensured the recovery of lithium or

[73] European Commission, n. 7 above, pp. 31–3, 37, 41, 47, 68. See also N.O. Bonsu, 'Towards a Circular and Low-Carbon Economy: Insights from the Transitioning to Electric Vehicles and Net Zero Economy' (2020) 256 *Journal of Cleaner Production*, article 120659, p. 2.

[74] J. Neumann et al., 'Recycling of Lithium-Ion Batteries: Current State of the Art, Circular Economy, and Next Generation Recycling' (2022) 12(17) *Advanced Energy Materials*, article 2102917, p. 2; European Commission, n. 29 above, p. 3; European Commission, n. 7 above, p. 31.

[75] Batteries Directive, n. 15 above, Arts 10(2), 3(17).

[76] European Commission, n. 7 above, pp. 37–39; Neumann et al., n. 74 above, p. 2; Stichting Stibat Services, *Annual Report 2021* (Stichting Stibat, 2021), p. 7.

[77] See, *inter alia*, Farmer & Watkins, n. 41 above, p. 27; Danthinne & Picard, n. 40 above, p. 394; Dawson, Ahuja & Lee, n. 22 above, p. 139; Neumann et al., n. 74 above, p. 2.

[78] Batteries Directive, n. 15 above, Annex III Part B. See also Danthinne & Picard, n. 40 above, p. 398.

[79] Batteries Directive, n. 15 above, Annex III Part B; Dawson, Ahuja & Lee, n. 22 above, p. 140.

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lithium-ion batteries in general.[80] Furthermore, the recycling targets themselves, including their calculation method, have been criticized for interpretative ambiguity and unnecessary complexity, leading to misreporting and differences in implementation between Member States.[81]

More generally, the waste management provisions of the Batteries Directive have been criticized for their varying provisions across battery classification, especially for failing to adequately address the management of waste industrial batteries.[82] Criticism was also directed at the inability of the Directive to keep up with incorporating new (technological) developments, such as those relating to battery chemistries and recycling technologies.[83]

Management of waste batteries under the Batteries Regulation

The Batteries Regulation appears to be an improvement on many of the above-mentioned issues. Regarding the collection of waste batteries, it provides more detail on the separate collection not only of waste portable batteries, but also waste LMT, SLI, industrial, and EV batteries.[84] In view of the environmental impact and loss of materials caused by waste batteries not being separately collected, the Regulation gradually increases the collection target for portable batteries. It also introduces a similar collection target for LMT batteries,[85] although, remarkably, it does not extend this requirement to the other three battery categories, for which no collection targets exist.[86]

Furthermore, the Batteries Regulation currently still maintains the criticized methodology for calculating collection targets, which will make meeting the increased collection targets challenging. However, the Regulation states that this methodology should be reviewed to reflect the actual volume of batteries available for collection, and the Joint Research Centre has since recommended adopting an 'available for collection' methodology.[87]

With regard to the recycling of waste batteries, the Regulation gradually introduces stricter targets for recycling efficiency and material recovery, with the aim of

[80] European Commission, n. 7 above, p. 34; L. Olsson, 'Circular Business Models for Extended EV Battery Life' (2018) 4(4) *Batteries*, article 57, p. 8; Dawson, Ahuja & Lee, n. 22 above, p. 140.

[81] European Commission, n. 7 above, p. 43; M. Green, 'Aspects of Battery Legislation in Recycling and Re-use: Perspectives from the UK and EU Regulatory Environment' (2017) 61(2) *Johnson Matthey Technology Review*, pp. 87–92, at 88.

[82] Ahuja, Dawson & Lee, n. 9 above, p. 243; Albertsen et al., n. 10 above, p. 7; Malinauskaite, Anguilano & Schmidt Rivera, n. 22 above, p. 5.

[83] European Commission, n. 29 above, p. 6; Ahuja, Dawson & Lee, n. 9 above, p. 243; Eleftheriadis et al., n. 43 above, p. 2; E. Mossali et al., 'Lithium-ion Batteries Towards Circular Economy: A Literature Review of Opportunities and Issues of Recycling Treatments' (2020) 264(30) *Journal of Environmental Management*, article 110500, p. 9.

[84] Batteries Regulation, n. 13 above, Arts 59–61.

[85] Ibid., Arts 59, 60; Recital 108.

[86] Ibid., Art. 61.

[87] Ibid., Arts 59(7), 60(8); Recitals 108, 110; S. Bobba et al., *Technical Specification for a Harmonised Methodology to Calculate Appropriate Collection Rates for Waste Portable and Light Means of Transport (LMT) Batteries* (Publications Office of the EU, 2024).

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guaranteeing that these materials are recovered within the battery value chain and returned as secondary materials.[88] The recycling efficiency targets are expanded with lithium-ion-based batteries as a separate category, reflecting their growing importance and application.[89] Although the criticized rules on the calculation of and reporting on recycling efficiency will continue to apply for the time being, the Recitals in the Regulation state that these rules will be reviewed by the European Commission.[90]

Moreover, the Batteries Regulation fulfils the frequently mentioned incentive to introduce material-specific recovery targets for cobalt, copper, lead, lithium, and nickel.[91] Such targets could provide an incentive for more effective and efficient collection, and contribute to ensuring high-quality recovery of materials. This could stimulate the internal market for secondary materials, which, in turn, would contribute to meeting the recycled content requirements.[92] Some interviewees agreed with this line of reasoning and welcomed these new targets, but several others highlighted the practical difficulties of recovering materials in general, particularly recovering materials of sufficiently high quality. These challenges add to the currently non-existent recycling infrastructure in the Netherlands and the limited recycling infrastructure the EU for certain battery chemistries. Consequently, the current recycling outputs fall short of meeting the demand of the growing batteries market.[93] Moreover, it is important to note that high-quality recycling not only can have significant adverse impacts as a result of the hazardous chemicals and high-energy demand involved in the process but also may reduce the overall quantity of recyclate. Considering all these aspects, it is relevant to mention that the Batteries Regulation enables the European Commission to revise the recycling efficiency and material recovery targets, and to introduce new targets, where appropriate, as a result of market developments as well as technical and scientific progress.[94]

88 Batteries Regulation, n. 13 above, Recital 115.

89 Ibid., Art. 71; see also Dawson, Ahuja & Lee, n. 22 above, p. 140; Thompson et al., n. 42 above, p. 7598.

90 Batteries Regulation, n. 13 above, Recital 115. It should be noted that, after finalizing this research, the methodology for the calculation and verification of rates for recycling efficiency and recovery of materials from waste batteries has been updated with the introduction of Commission Delegated Regulation (EU) 2025/606 of 21 March 2025 supplementing Regulation (EU) 2023/1542 by Establishing the Methodology for Calculation and Verification of Rates for Recycling Efficiency and Recovery of Materials from Waste Batteries, and the Format for the Documentation. See previously Commission Regulation (EU) No 493/2012 laying down, pursuant to Directive 2006/66/EC, Detailed Rules regarding the Calculation of Recycling Efficiencies of the Recycling Processes of Waste Batteries and Accumulators [2012] OJ L 151/9. See further M. Orefice et al., *Technical Suggestions for the Rules for Calculation and Verification of Rates for Recycling Efficiency and Recovery of Materials of Waste Batteries* (Publications Office of the EU, 2024).

91 Batteries Regulation, n. 13 above, Art. 71(2); Annex XII, Part B and Part C.

92 See, *inter alia*, Farmer & Watkins, n. 41 above, pp. 33–4.

93 A. Månberger, 'Critical Raw Material Supply Matters and the Potential of the Circular Economy to Contribute to Security' (2023) 58(2) *Intereconomics*, pp. 74–8, at 76; Farmer & Watkins, n. 41 above, pp. 22–3.

94 Batteries Regulation, n. 13 above, Art. 71(5), 71(6).

Extended producer responsibility

The Batteries Directive established the principle of EPR for batteries, making producers of batteries organizationally and financially responsible for fulfilling the above-mentioned waste management requirements.[95] EPR is considered a key part of the EU's CE transition and is said to be an effective tool for transforming towards a CE model.[96] EPR has led to the collection and recovery of waste batteries,[97] and has been deemed necessary by several interviewees because of the negative residual value of waste batteries. However, in the light of the CE transition, several shortcomings and issues have been identified regarding EPR for batteries.

In the first place, EPR has not led to increased resource efficiency, nor does it appear that EPR has had a positive impact on circular battery design (see Section 2.2).[98] Furthermore, the existing EPR framework has been criticized for hampering second-life operations of batteries. EPR schemes are evaluated based solely on collection targets, which can be considered contradictory to stimulating higher-tier waste hierarchy strategies,[99] such as reuse.[100]

The relationship between EPR and the repair and reuse of batteries has raised additional issues. For example, uncertainties exist regarding which actor holds producer responsibility.[101] Furthermore, the interviews showed that, at least in the Netherlands, the EPR schemes – and especially the producer responsibility organization in the case of collective fulfilment – play a decisive role in stimulating and enabling repair, remanufacture, reuse, and repurposing, as companies depend on them for their supply. While these organizations aim to become as circular as possible, some interviewees criticized their role and functioning. Concerns were raised that the producer responsibility organization for portable and electric bicycle batteries is prioritizing repurposing over repair and remanufacturing, and that cooperation with repurposing companies is not always going well. These issues were also linked to the uncertainty about whether batteries are classified as waste.

The EPR framework under the Batteries Directive has also been criticized for its different approaches according to battery classification.[102] Especially with regard to industrial batteries, EPR obligations were considered vague and insufficient.[103] The

[95] Batteries Directive, n. 15 above, Arts 8, 12, 16.

[96] See, *inter alia*, Dawson, Ahuja & Lee, n. 22 above, p. 133; C. Giosuè et al., 'An Exploratory Study of the Policies and Legislative Perspectives on the End-of-Life of Lithium-Ion Batteries from the Perspective of Producer Obligation' (2021) 13(20) *Sustainability*, article 11154, p. 17; J. Baars et al., 'Circular Economy Strategies for Electric Vehicle Batteries Reduce Raw Material Reliance' (2021) 4 *Nature Sustainability*, pp. 71–9, at 76.

[97] European Commission, n. 7 above, p. 47.

[98] Ibid.

[99] The waste hierarchy provides a priority order in waste prevention and management legislation and policy; it is as follows: waste prevention, preparing for reuse, recycling, other recovery, and disposal; see Directive 2008/98/EC on Waste and Repealing Certain Directives [2008] OJ L 312/3 (WFD), Art. 4.

[100] European Commission, n. 7 above, p. 46.

[101] See, *inter alia*, ibid., p. 34–35; Albertsen et al., n. 10 above, p. 8; Olsson, n. 80 above, p. 8.

[102] Batteries Directive, n. 15 above, Art. 8(16); see also Ahlers et al., n. 42 above, p. VII.

[103] Batteries Directive, n. 15 above, Arts 8(3), 12, 16(1)(b), 16(5); Ahuja, Dawson & Lee, n. 9 above, p. 243; Danthinne & Picard, n. 40 above, pp. 394, 399.

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interviews confirmed that this has led to confusion and practical obstacles, with interviewed governmental officials adding that their oversight over this battery category is more limited. In the Netherlands, this 'omission' has been resolved for EV and electric bicycle batteries. For these batteries, producer responsibility organizations have been established, which include organizational and financial structures. This has not been the case for the remaining types of industrial battery, where implementing EPR, especially financial responsibility, is further complicated by the long lifespans of these batteries. All in all, not only with regard to industrial batteries[104] but also more generally, the extent to which the EPR framework has contributed to the CE transition has been criticized.

The Batteries Regulation continues to apply the instrument of EPR for the management of batteries at their EoL stage.[105] EPR is still considered as being able to contribute to reducing overall resource use, waste generation, and the adverse impacts of waste battery management.[106] To this end, the Regulation introduces new and more comprehensive rules. Producers are financially responsible for separately collecting, treating, and recycling batteries. Additionally, they are required to carry out surveys of mixed collected municipal waste, to report on (waste) batteries and to provide information to end users and waste operators about both appropriate management and reuse options for waste batteries.[107] These EPR obligations are now detailed for each battery category, including EV and industrial batteries.

The Batteries Regulation states that EPR could reduce the generation of waste batteries and thus seems to refer to the influence of EPR on prior stages in the battery value chain.[108] Despite not explicitly mentioning the potential of EPR to incentivize circular battery design, the Regulation requires the use of modulated fees in the case of collective fulfilment. These modulations are to be based, at least, on the battery category and chemistry and, where appropriate, also on rechargeability, the level of recycled content, whether the batteries have been subject to (preparation for) reuse or repurposing, and their carbon footprint.[109] Through these fees, EPR might increase its influence on the product stage of batteries. However, the interviewed producer responsibility organizations expressed mixed opinions on the desirability of fee modulation, indicating that its implementation poses significant challenges.

Moreover, the Batteries Regulation addresses the previously existing uncertainties regarding the transfer of responsibility in the case of (preparations for) reuse, repurposing or remanufacturing: EPR should apply also to the economic operators that place batteries resulting from these operations on the market.[110] Interviewees across the value chain perceived this development to be logical and desirable.

[104] Danthinne & Picard, n. 40 above, pp. 394, 399; Dawson, Ahuja & Lee, n. 22 above, p. 139.
[105] Batteries Regulation, n. 13 above, Recital 101.
[106] Ibid., Recital 95.
[107] Ibid., Art. 56; Recital 101.
[108] Ibid., Recital 95.
[109] Ibid., Art. 57(2)(a). In the case of collective fulfilment, fee modulation was already required where possible: WFD, n. 99 above, Art. 8a(4)(b).
[110] Batteries Regulation, n. 13 above, Art. 56(2), Recital 102.

Nonetheless, the evaluation of EPR schemes for portable and LMT batteries is still based on reaching the criticized collection targets.[111]

The focus of the CE, and accordingly the Batteries Regulation, on higher-tier waste hierarchy strategies also raised more fundamental questions regarding the extent to which the instrument of EPR itself aligns with the CE.[112] An interviewed repairer and government official questioned whether the current EPR framework will remain necessary for all battery categories when economically viable alternative routes for those 'waste' batteries exist. Although an interviewed producer responsibility organization argued that EPR will remain necessary as batteries will become waste at some point, alternatives to the current framework were mentioned in both the literature and interviews. These alternatives ranged from a redirection to individual producer responsibility,[113] extending producers' responsibility so that they retain ownership of and take back their own products, to redrafting the whole EPR concept to prevent sub-optimizing a system that originally did not focus sufficiently on higher-tier waste hierarchy strategies. Another suggestion, which relates to the criticism of the position of producer responsibility organizations, is to introduce a circular value chain management organization. This independent entity would bring together all economic actors related to value retention options to focus on the CE strategy for the product in question.[114] Although additional areas of improvement could be considered to better align EPR with higher-tier waste hierarchy strategies, overall, the Batteries Regulation shows progress.

Transport of waste batteries

Waste batteries are frequently transported for waste management purposes, both within and outside the EU. In the Netherlands, collected and sorted waste batteries are always exported abroad as there is currently no domestic operational recycling facility. Transport of waste batteries also takes place for preparation for reuse and repurposing operations.

However, at the moment, these transportations and the treatments of these (waste) batteries have been further complicated by the Waste Shipment Regulation (WSR).[115] Both the literature and the interviews showed that the possibility of transporting batteries is hampered by financial and administrative burdens, especially because of

[111] Ibid., Art. 69 and Annex XI. However, see ibid., Arts 59(7), 60(8).

[112] Albertsen et al., n. 10 above, p. 11; Danthinne & Picard, n. 40 above, p. 399; Dawson, Ahuja & Lee, n. 22 above, p. 133.

[113] Dawson, Ahuja & Lee, n. 22 above, p. 133.

[114] W. Vermeulen et al., *White Paper on Pathways for Extended Producer Responsibility on the Road to a Circular Economy* (Utrecht University, 2021), pp. 26–7. A similar provision was deleted from the Batteries Regulation Proposal (Art. 47 (11)).

[115] Regulation (EC) No. 1013/2006 on Shipments of Waste [2006] OJ L 190/1. The United Nations Economic Commission for Europe (UNECE), European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) (Geneva (Switzerland), 30 Sept. 1957, in force 29 Jan. 1968, last amended in 2022 (ADR 2023), in force 1 Jan. 2023, available at: https://unece.org/transport/standards/transport/dangerous-goods/adr-2023-agreement-concerning-international-carriage) can also play a role but falls outside the scope of this research. See also Thompson et al., n. 42 above, p. 7598; Olsson, n. 80 above, p. 8.

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the classification of batteries as hazardous (waste).[116] Although this classification is understandable and strict regulation is necessary, interviewees said that the current situation leads to delays, as authorities take a long time to process applications. According to interviewed second-life and waste management operators, these interruptions and corresponding costs are exacerbated by the fact that legal requirements and classifications differ between Member States. At the same time, one interviewee revealed that these ambiguities are exploited by stakeholders, as they bypass Member States that apply stricter interpretations. This remark aligns with the picture that emerged from the interviews, namely that the current legislation on the transport of (waste) batteries is often approached creatively because of its strictness, such as willingly misclassifying batteries as non-hazardous. The fact that companies get away with this deliberate act is in line with the observation of an interviewed notified body and waste management operator, who stated that enforcement of waste battery transports is difficult for authorities and that there is a general lack of enforcement. Such shortcomings can lead to unfair or undesirable situations, such as the existence of free riders, illegal waste transports, and questionable exports of used batteries to non-member states of the Organisation for Economic Co-operation and Development (OECD), where these batteries can have negative environmental impacts.[117] At the time of this research, the old WSR was still in place, whereas the new WSR has now entered into force.[118] Although further research is required, the new WSR aims not only to improve monitoring and enforcement but also to facilitate shipments for reuse, repair, refurbishment or recycling within the EU.[119]

The Batteries Regulation continues to allow shipment for treatment of waste batteries outside a Member State or the EU, provided that these shipments comply with the relevant legal framework. The Batteries Regulation also allows this treatment outside the EU to count towards its recycling efficiency and targets, provided that the waste management operator reports and proves that proper treatment has taken place.[120] The Regulation specifically addresses the prospective increase in batteries that will be transported for repair, (preparation for) reuse and repurposing. To this end, it also contains a provision allowing Member States to inspect shipments of used batteries in order to distinguish between used and waste batteries.[121] Furthermore, its Recitals acknowledge the need to revise the List of Waste to reflect all battery chemistries to enable proper sorting and reporting,[122] which has resulted in an update

[116] Thompson et al., n. 42 above, p. 7598; Olsson, n. 80 above, p. 8; Kampker et al., n. 71 above, p. 3; Hill et al., n. 10 above, p. 169.
[117] Farmer & Watkins, n. 41 above, p. 38; Hill et al., n. 10 above, p. 164.
[118] Regulation (EU) 2024/1157 on Shipments of Waste, amending Regulations (EU) No 1257/2013 and (EU) 2020/1056 and repealing Regulation (EC) No 1013/2006 [2024] OJ L.
[119] Ibid., Title VII Ch. 2 and Title II.
[120] Batteries Regulation, n. 13 above, Art. 72(1), 71(3); Recital 116.
[121] Ibid., 72(2); Recital 117.
[122] Ibid., Recital 116; Commission Decision replacing Decision 94/3/EC establishing a List of Wastes pursuant to Article 1(a) of Council Directive 75/442/EEC on Waste and Council Decision 94/904/EC establishing a List of Hazardous Waste pursuant to Article 1(4) of Council Directive 91/689/EEC on

introducing new (hazardous) waste codes.[123] According to the two interviewed waste operators, creating a level playing field in the EU in this way would be desirable. Altogether, the Batteries Regulation appears to address, to some extent, the need for increased enforcement and a level playing field regarding the transport of waste batteries. In the literature and interviews, however, more far-reaching suggestions were made. These included the introduction of a simpler, fast-track system for waste batteries, agreements between Member States to facilitate transport of waste batteries with exemptions on WSR requirements and an increase in actual controls.[124]

2.4. Lifetime-Extending and Second-Life Operations for Batteries

Used batteries, depending on their classification as waste or otherwise, can be subject to reuse, remanufacturing, repurposing, preparation for reuse, and preparation for repurposing.[125] These operations can prolong the lifetime of batteries or their components and are claimed to mitigate the environmental impact of batteries.[126] Repair, remanufacturing, and (preparation for) reuse and repurposing are higher-tier waste hierarchy strategies and can therefore be considered to be in line with CE objectives.[127] These value retention options are particularly relevant for used LMT, EV, and industrial batteries, for which a market is currently emerging.[128]

Barriers to lifetime-extending and second-life operations

In the Netherlands, several companies are already reusing, repairing, and remanufacturing batteries as well as repurposing them as energy storage systems. Although these businesses prove that it is has been economically feasible and (legally) possible, the Batteries Directive has been criticized in the literature for not being well adapted to second-life options for batteries[129] and for focusing on recycling rather than higher-tier waste hierarchy strategies.[130] The Directive did not consider the second life of batteries and lacked definitions for concepts such as reuse, repurposing, and remanufacturing.[131] It also did not contain any guidelines or incentives such as

Hazardous Waste 1147 [2000] OJ L 226/3, and WFD, n. 99 above, Art. 7. The List of Waste provides the common terminology for the classification of waste in the EU.

123 Commission Delegated Decision (EU) .../... amending Decision 2000/532/EC as regards an Update of the List of Waste in Relation to Battery-related Waste, 5 Mar. 2025, C(2025) 1360 final. See also L. Egle et al., *Technical Recommendations for the Targeted Amendment of the European List of Waste Entries Relevant to Batteries* (Publications Office of the EU, 2024).

124 Hill et al., n. 10 above, p. 167; Groupe Renault, 'Innovation Deal. From E-Mobility to Recycling – The Virtuous Loop of Electric Vehicle: Assessment of Legal and Regulatory Barriers to the Optimization of EV Battery Life Cycle', 10 Oct. 2018, p. 52; Farmer & Watkins, n. 41 above, p. 38.

125 Batteries Regulation, n. 13 above, Art. 3(29), 3(30), 3(32); Recitals 16, 17.

126 Anand et al., n. 28 above, p. 34.

127 See, *inter alia*, also Bonsu, n. 73 above, p. 10.

128 Batteries Regulation, n. 13 above, Recital 118.

129 Dawson, Ahuja & Lee, n. 22 above, p. 141.

130 Groupe Renault, n. 124 above, p. 52.

131 See, *inter alia*, Green, n. 81 above, p. 88; A. Nurdiawati & T.K. Agrawal, 'Creating a Circular EV Battery Value Chain: End-of-Life Strategies and Future Perspective' (2022) 185(5) *Resources, Conservation and Recycling*, article 106484, p. 11.

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targets for reuse or repurposing.[132] Moreover, as previously mentioned, under the Batteries Directive it was unclear who was responsible for the EoL management of the second-life battery.[133] Altogether, this led to legal uncertainty, which hampered or even prevented the implementation of such strategies.[134]

Waste legislation, more generally, was also identified as hindering lifetime-extending and second-life operations for (waste) batteries. In particular, the classification of used batteries as waste is an issue, as handling the latter requires waste permits, complicates transport, and overall generates additional administrative and financial burdens.[135] The waste status was pointed out as contributing negatively to enabling battery repair, in particular,[136] as all repairers would need waste permits. Two interviewees, including one producer responsibility organization, stated that the issues surrounding the classification of used batteries as waste leads to bypassing repair in favour of lower waste hierarchy strategies, such as preparation for reuse and repurposing or even recycling, as these options lead to an end-of-waste status.

Regulating lifetime-extending and second-life operations under the Batteries Regulation

The Batteries Regulation does appear to be adapted to lifetime-extending and second-life options for batteries.[137] The Regulation contains definitions on remanufacturing and (preparation for) reuse and repurposing. Although it lacks targets or standards for reuse or repurposing, multiple provisions specifically take into account, or even aim to support, lifetime-extending and second-life possibilities for batteries.[138] Examples include provisions on determining the state of health and expected lifetime of used batteries, requiring producers to provide information to end users, distributors, and waste treatment operators on preparation for reuse or repurposing, and clarifying the transfer of EPR.[139] In particular, the increased focus on providing battery information is in line with what in the literature has been deemed necessary for second-life operations.[140] Despite the fact that repair is not included as detailed in the Regulation, an interviewed repairer stated that this sector will benefit as well. Altogether, several interviewees across the value chain confirmed that the focus on (preparation for) reuse, (preparation for) repurposing, and remanufacturing is a positive development.

Although the Batteries Regulation appears to create a framework that facilitates lifetime-extending and second-life operations for batteries, some critical remarks,

[132] See, *inter alia*, M.T. Islam & U. Iyer-Raniga, 'Lithium-Ion Battery Recycling in the Circular Economy: A Review' (2022) 7(3) *Recycling*, article 33, p. 2; Hill et al., n. 10 above, pp. 126–7, 166; E. Drabik & V. Rizos, *Prospects for Electric Vehicle Batteries in a Circular Economy* (CEPS, 2018), p. 23.

[133] Kampker et al., n. 71 above, p. 9.

[134] See, *inter alia*, Dawson, Ahuja & Lee, n. 22 above, p. 141; Alamerew & Brissaud, n. 7 above, p. 8; European Commission, n. 7 above, pp. 34–5, 69.

[135] Hill et al., n. 10 above, p. 162; Groupe Renault, n. 124 above, p. 51.

[136] See, e.g., European Commission, n. 7 above, pp. 34–5; Farmer & Watkins, n. 41 above, p. 34.

[137] Nurdiawati & Agrawal, n. 131 above, pp. 11–2.

[138] Batteries Regulation, n. 13 above, Recitals 16–18, 118.

[139] Ibid., Arts 14, 74(1)(c), 74(2), 74(3), 56(2).

[140] See, *inter alia*, European Commission, n. 7 above, pp. 26–7; Hagelüken & Goldmann, n. 11 above, p. 554; Harper et al., n. 42 above, p. 77.

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untapped potential, and challenges were identified in the literature and the conducted interviews. The Regulation's facilitation of these operations has not been universally welcomed, according to the interviewees. Interestingly, interviewed repairers and second-life operators indicated that facilitating reuse, repurposing, and remanufacturing would not have been necessary for them at all, with some fearing that such facilitation might result in the loss of their competitive advantage in the market. Interviewees also mentioned more practical issues, ranging from difficulties related to safety and corresponding liability, technical difficulties related to performance, the limited availability of used batteries, and concerns for reputational damage.[141] Interviewed government officials added that the minimum requirements for shipments of used batteries, which aim to distinguish between used and waste batteries, are difficult to translate to the situation in practice. These requirements could, in fact, hamper repair and other R-strategies, as following these criteria causes batteries to be very quickly classified as waste.

Furthermore, in both the literature and interviews, suggestions were made to further incentivize lifetime-extending and second-life operations for batteries. Examples included setting quality standards for used batteries and introducing reuse and repurposing targets, as well as the possibility of introducing EU-wide end-of-waste criteria for waste batteries under the Waste Framework Directive (WFD).[142] This could remove the currently existing differences between Member States regarding the waste status of batteries and thus create a level playing field.[143] Moreover, in both the literature and interviews, it was pointed out that a dilemma exists between stimulating recycling, on the one hand, and higher-tier waste hierarchy strategies, on the other. Lifetime-extending and second-life operations can delay the availability of waste batteries for recycling and recycled materials.[144] Conversely, recycling targets and recycled content requirements could incentivize (high-quality) recycling over higher value retention options. In addition, the higher-tier waste hierarchy strategies are said to be not necessarily more sustainable, such as when a higher value retention option has a greater overall environmental impact.[145] These examples show the need to pay continuous attention to finding the proper balance between the benefits of (preparation for) reuse, repurposing and remanufacturing, and other strategies.

[141] See also P. van Tichelen, G. Mulder & A. Durand, *Preparatory Study on Ecodesign and Energy Labelling of Rechargeable Electrochemical Batteries with Internal Storage under FWC ENER/C3/2015-619-Lot 1* (European Union, 2019), p. 489; Ahuja, Dawson & Lee. n. 9 above, pp. 239–40; Alamerew & Brissaud, n. 7 above, pp. 10–1.

[142] WFD, n. 99 above, Art. 6.

[143] Groupe Renault, n. 124 above, pp. 49–50; Farmer & Watkins, n. 41 above, p. 34; Van Tichelen, Mulder & Durand, n. 141 above, pp. 487–8.

[144] Albertsen et al., n. 10 above, p. 11; F. Rossi et al., 'Environmental Optimization Model for the European Batteries Industry based on Prospective Life Cycle Assessment and Material Flow Analysis' (2023) 183 *Renewable and Sustainable Energy Reviews*, article 113485, p. 13.

[145] Ahuja, Dawson & Lee, n. 9 above, p. 242; K. Richa, C.W. Babbitt & G. Gaustad, 'Eco-Efficiency Analysis of a Lithium-Ion Battery Waste Hierarchy Inspired by Circular Economy' (2017) 21(3) *Journal of Industrial Ecology*, pp. 715–30, at 726.

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3. Analysis

Section 2 shows that the Batteries Directive already embodied CE aspects and life-cycle thinking to a certain extent. However, the evaluation of the Batteries Directive as well as its identified barriers and incentives make clear that issues remained and the relevant provisions did not fully reflect the importance of the CE transition.[146] The Batteries Regulation has addressed many of the highlighted issues that existed predominantly under the Batteries Directive and has implemented many of the identified incentives for the CE transition.[147] Overall, the Regulation appears to reflect CE and resource efficiency policies much better than its predecessor, despite remaining challenges and the need for additional improvements.

3.1. The Batteries Regulation and the Circular Economy

The aim of a CE is better reflected in the objectives of the Batteries Regulation and the provisions in which they are operationalized. Examples include the definition of value retention strategies, the recycled content requirements, and the reinforced provisions on collection and recycling of waste batteries, including the provisions on material recovery. The Regulation not only addresses CE practices; it also better reflects the waste hierarchy, which is most clearly indicated by the increased focus on lifetime-extending and second-life options.

Furthermore, by regulating the entire life cycle of batteries and emphasizing specific provisions that consider the whole life cycle, the Batteries Regulation demonstrates a strong commitment to life-cycle thinking. This approach is considered fundamental to a CE and a guiding principle in product legislation.[148] Taking a life-cycle approach is important to unlock synergies in pursuance of CE objectives.[149] For instance, the removability of batteries influences the achievement of the collection targets, which is connected to the recycling targets and ultimately affects compliance with recycled content requirements.[150] Similarly, information-providing instruments, such as labels or the battery passport,[151] could facilitate lifetime-extending and second-life options for batteries.[152] In addition, the Batteries Regulation also explicitly recognizes the interaction and need for coherence with other legal acts, such as the

[146] See also European Commission, n. 7 above, pp. 9–11, 31–5, 41, 47, 60–5, 68–9; Green, n. 81 above, p. 88.

[147] See, *inter alia*, Danthinne & Picard, n. 40 above; Albertsen et al., n. 10 above. See also Rizos & Urban, n. 71 above, pp. 5, 7.

[148] T.J. de Römph & J.M. Cramer, 'How to Improve the EU Legal Framework in View of the Circular Economy' (2020) 38(3) *Journal of Energy & Natural Resources Law*, pp. 245–60, at 247.

[149] Batteries Regulation, n. 13 above, Recital 3.

[150] Ibid., Recital 105; European Commission, n. 7 above, p. 37–9; Farmer & Watkins, n. 41 above, p. 33.

[151] Batteries Regulation, n. 13 above, Recital 44; M.T. Lotz et al., 'Potentials and Prerequisites on the Way to a Circular Economy: A Value Chain Perspective on Batteries and Buildings' (2022) 14(2) *Sustainability*, article 956, p. 6; Thompson et al., n. 42 above, p. 7588.

[152] Farmer & Watkins, n. 41 above, p. 36; Van Tichelen, Mulder & Durand, n. 141 above, p. 475.

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REACH Regulation,[153] the Ecodesign for Sustainable Products Regulation,[154] and the collection of waste batteries through collection schemes for WEEE or ELVs.[155]

Moreover, the fact that the Batteries Directive is replaced by a regulation has been welcomed in both the literature and in almost all interviews, particularly in the context of the CE transition. A regulation creates a more harmonized legal framework and aims to reduce the currently fragmentated implementation, helping to ensure a level playing field.[156] In addition, aspects such as more detailed provisions, the introduction of clearer definitions, and the increased attention for standardization are considered to contribute positively to a harmonized internal market, as well as to the achievement of CE and resource efficiency objectives.[157] In short, the Batteries Regulation can be considered a welcome development for the CE transition.

3.2. Remaining Challenges and Additional Improvements

Despite the Batteries Regulation's improved alignment with and reflection of CE objectives, a critical examination reveals that challenges remain and there is room for improvement.

Challenges regarding implementation

The interviews indicate that the practical implementation of the Batteries Regulation will be somewhat challenging for industry, especially as a result of the expected administrative burden, increased costs of compliance, and heightened difficulties in gaining and verifying all required information throughout the value chain.[158] The multitude of legal requirements and their accompanying differing timelines were also pointed out by interviewees as adding complexity. Other parts of the Batteries Regulation still need further clarification through delegated acts, which are still to be adopted, increasing overall legal uncertainty.[159] Several interviewees – start-ups and scale-ups, in particular – mentioned that while specific knowledge is often needed to understand and implement the legislation, they themselves lack the necessary manpower or capacity for gaining that knowledge. A more general concern is that many interviewed stakeholders across the value chain admitted to having no awareness of the applicable legislation, with some perceiving this as a larger trend in the sector.

Furthermore, it appears that, at least in the Netherlands, implementation might be challenging for the government as well. Interviewed government officials

[153] Batteries Regulation, n. 13 above, Arts 6, 86, Recitals 21, 22, 24, 25.
[154] Ibid., Art. 78(a), Recital 126; Regulation (EU) 2024/1781 establishing a Framework for the Setting of Ecodesign Requirements for Sustainable Products, amending Directive (EU) 2020/1828 and Regulation (EU) 2023/1542 and repealing Directive 2009/125/EC [2024] OJ L (Ecodesign Regulation).
[155] Batteries Regulation, n. 13 above, Arts 59, 60, 61; Recitals 97, 106, 107.
[156] Ibid., Recital 10.
[157] Hill et al., n. 10 above, pp. 166–7; Farmer & Watkins, n. 41 above, p. 34; Bonsu, n. 73 above, p. 9.
[158] See also Ahlers et al., n. 42 above, p. 80; Danthinne & Picard, n. 40 above, p. 394; Hagelüken & Goldmann, n. 11 above, p. 557.
[159] See, e.g., Batteries Regulation, n. 13 above, Arts 7, 8, 53; Recitals 28, 33, 94.

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explained that despite the integrated approach of the Batteries Regulation, implementation at the national level is divided between various ministries and executive agencies. Furthermore, several interviewees questioned the enforceability of the Regulation. They mentioned not only their own experience with a general lack of enforcement of (other) batteries-related legislation, but also a lack of manpower and knowledge at enforcement authorities. This led interviewed stakeholders to be concerned about their own competitiveness if the combination of a lack of compliance and lack of enforcement leads to an uneven playing field, both within the EU and globally.

Moreover, rigid and complex legislation can hamper innovation and slow down the CE transition altogether. Eventually, such legislation might even discourage investment and lead to lower application for batteries, which in turn could have a negative effect on decarbonization and the energy transition.[160] The fact that legislation moves slowly and could become quickly outdated in this rapidly developing sector poses an additional complicating factor.[161] Although the Batteries Regulation itself often refers to the possibility of adjusting certain aspects or requirements through delegated acts in response to technological developments or market situations,[162] the importance of the stability of the legal framework, which is necessary for facilitating investment, should not be overlooked.[163] Additional solutions could include providing experimentation possibilities for start-ups or adjusting the scope of certain provisions, similar to the due diligence obligations, by making them applicable only to economic operators with certain turnover thresholds. Altogether, these examples show that aspects such as feasibility, enforceability, and alignment with practical realities should not be overlooked in a comprehensive legal framework like the Batteries Regulation.

Alignment with the waste hierarchy

The Batteries Regulation demonstrates a clear improvement in terms of its focus on the higher-tier waste hierarchy strategies through its provisions on lifetime-extending and second-life options. However, as discussed above, the Regulation could have addressed repair in greater detail, and targets for reuse or repurposing of batteries could also have been considered. In addition, the Regulation's collection and recycling targets could incentivize recycling over lifetime-extending and second-life operations for batteries. Even though these recycling targets and recycled content requirements also contribute to the CE transition, by encouraging closed-loop recycling and reducing the dependency on primary resources,[164] such negative trade-offs should be taken into account.

Furthermore, the Regulation could have focused more on the highest value retention options, namely, to refuse or reduce the consumption of batteries. Although such a focus seems to contradict the fact that demand for batteries will increase

[160] Nurdiawati & Agrawal, n. 131 above, p. 12; H.E. Melin et al., 'Global Implications of the EU Battery Regulation' (2021) 373(6553) *Science*, pp. 384–7, at 385.
[161] Green, n. 81 above, p. 87; Alamerew & Brissaud, n. 7 above, pp. 9–10.
[162] See e.g., Batteries Regulation, n. 13 above, Arts 8(5), 8(6), 10(6), 11(4), 14(4), 71(5), 71(6).
[163] Melin et al., n. 160 above, p. 386–7; Nurdiawati & Agrawal, n. 131 above, pp. 11–2.
[164] Albertsen et al., n. 10 above, p. 11; Harper et al., n. 42 above, p. 76; Farmer & Watkins, n. 41 above, p. 22.

because of their key role in the energy transition, not all batteries fulfil such key functions. For example, interviewees criticized the trend of cordless equipment and emphasized the idea of restricting batteries in disposable products such as vapes. Currently, the Batteries Regulation addresses in its Recitals only a need to ensure that fewer low-performing non-rechargeable portable batteries of general use are placed on the market, and only by establishing objective requirements for their performance and durability.[165] In addition, consideration should be given to the necessity and desirability of other batteries and battery-powered products. Similar steps to those for the above-mentioned portable batteries should be taken, either in the Batteries Regulation itself or possibly through the legislation governing the product in question (as further discussed in Section 3.3).

Interaction within the legal framework

The inherent interlinkages that exist between the life-cycle stages, as well as the legislation governing them, must be considered for the Batteries Regulation's contribution to the CE to be successful. These interlinkages extend beyond the provisions of the Regulation itself, as several additional legal acts also regulate the life cycle of batteries. This highlights the need to pay attention to the effect of other legislation, as well as for streamlining the provisions of the Batteries Regulation with other legal acts, to prevent double regulation and inconsistencies. An example that makes clear how the provisions of the Regulation are interlinked with the legal framework of EU chemicals, product and waste legislation, more generally, are the issues regarding the waste status of batteries. It follows that even though the Batteries Regulation contains provisions that are in line with CE objectives and the waste hierarchy, adjustments or reconsiderations regarding the role of waste and waste legislation, including the WFD, might also be necessary.

Other issues that require attention in this respect are the need for streamlining provisions with the WEEE Directive and ELV Directive.[166] This also includes the identified difference in battery classification under the Batteries Regulation, Waste Shipment Regulation, and the Waste Statistics Regulation,[167] which could lead to misreporting and complicate managing notifications for waste transport.[168] In line with this, interviewed manufacturers and distributors expressed their fear of potential overlaps between the new information requirements of the Batteries Regulation and similar requirements from other legal acts, as well as between the Regulation's due diligence obligations and corporate social responsibility

[165] Batteries Regulation, n. 13 above, Recital 37.
[166] Danthinne & Picard, n. 40 above, p. 403; Dawson, Ahuja & Lee, n. 22 above, p. 136.
[167] Regulation (EC) No 2150/2002 on Waste Statistics [2002] OJ L 332/1.
[168] European Commission, n. 7 above, p. 62. However, see also Batteries Regulation, n. 13 above, Recital 116; European Commission, 'Waste Treatment: Amendment to the European List of Waste to Address Waste Batteries and Wastes from Treating Them', 5 Mar. 2025, available at: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/14016-Targeted-amendment-of-the-European-List-of-Waste-as-regards-waste-batteries-and-wastes-from-their-treatment_en.

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legislation.[169] This is also the case regarding other legislation, which regulates the battery value chain but falls outside the scope of this research, such as safety legislation or financial regulations.

When considering the text of the Batteries Regulation, its relation to other legislation has already been touched upon several times, such as its relationship with the REACH Regulation or with the WEEE Directive and ELV Directive.[170] This further clarifies the interrelationship within the legal framework and could contribute to avoiding double regulation and inconsistencies. Nevertheless, the challenges regarding interaction within the legal framework governing the life cycle of batteries is likely to remain an important issue, especially given the many legal acts that have recently been adopted or are currently proposed, such as the Ecodesign Regulation[171] or the proposal for the ELV Regulation.[172]

Moreover, considering the interaction between a battery's life-cycle stages and the legislation governing them is also important because of potential negative trade-offs or conflicting objectives. For example, due diligence requirements can have an unintended negative impact on the recycling market, as these requirements may lead to using fewer or no critical raw materials in batteries, which can make the recycling of certain batteries or battery chemistries less interesting from an economic perspective.[173] Another example has already been mentioned in Section 2.4 – namely, that recycling targets and recycled content requirements can negatively affect reuse or other second-life operations, and vice versa. It has also been pointed out that although high-quality recycling or second-life operations are more in line with the waste hierarchy, they are not necessarily more sustainable in terms of their environmental impact.[174] This observation reveals a more substantial need to find a balance within the legal framework between CE practices and sustainability objectives more broadly. In finding this balance, the newly introduced carbon footprint requirement in the Batteries Regulation could be insightful, but also the waste hierarchy provision itself provides guidance, as it states that departing from the waste hierarchy can be allowed in order to deliver the best overall environmental outcome.[175] After all, the aim of achieving circularity should be seen as a means to contribute to the EU's ambition to achieve a sustainable and climate-neutral economy.

Nevertheless, these negative trade-offs expose the complexity of balancing all these different aspects within the legal framework, including not only circularity, environmental impact and economic feasibility, but also technical possibilities,

[169] In this regard see also European Commission, 'Proposal for a Regulation amending Regulation (EU) 2023/1542 as regards Obligations of Economic Operators concerning Battery Due Diligence Policies', 21 May 2025, COM(2025) 258 final.
[170] Batteries Regulation, n. 13 above, Art. 6; Recitals 21, 22, 24, 25; Ch. VIII, Recitals 97, 107.
[171] N. 154 above.
[172] European Commission, 'Proposal for a Regulation on Circularity Requirements for Vehicle Design and on Management of End-of-life Vehicles, amending Regulations (EU) 2018/858 and 2019/1020 and repealing Directives 2000/53/EC and 2005/64/EC', 13 July 2023 COM(2023) 451 final.
[173] Farmer & Watkins, n. 41 above, p. 22; Melin et al., n. 160 above, p. 386.
[174] Richa, Babbitt & Gaustad, n. 145 above, p. 726; Farmer & Watkins, n. 41 above, p. 23.
[175] WFD, n. 99 above, Art. 4(2).

equitable supply chains, and safety considerations.[176] Continuous attention must be paid to identifying these (potential) negative trade-offs within the legal framework, in order to avoid or prevent unintended consequences and adverse effects from materializing.

3.3. The Batteries Regulation: A Blueprint for Legislation for the Circular Economy?

The Batteries Regulation is expected to contribute to the creation of a legal framework that stimulates the achievement of CE objectives and incorporates life-cycle thinking. It is the first regulation that fully reflects the fact that all life-cycle stages of batteries are inherently interlinked. This Regulation has therefore been named as a potential guideline for regulating the circular transition of other product groups or sectors.[177] Yet, the analysis identified some remaining challenges and raises additional questions about the approach taken in the Regulation.

The Batteries Regulation regularly refers to its interaction with other legal acts. Some of these references highlight potential difficulties that could exist with regard to taking a comprehensive life-cycle approach for a specific product sector. For example, the Batteries Regulation states that the revision of the ELV Directive would be appropriate to regulate the removability and replaceability of SLI and EV batteries in motor vehicles.[178] The Regulation also states that it is considered appropriate to set performance and durability requirements for batteries used in mobile phones and tablets, as well as for portable batteries in other appliances in (sometimes already existing) ecodesign regulations, instead of the Batteries Regulation.[179] These examples raise the question of how the decision to regulate these product aspects outside the Batteries Regulation relates to the premise that the Regulation aims to exhaustively regulate the entire life cycle of all batteries. This might even be considered a missed opportunity. The question could also be raised as to why the possibilities of the Ecodesign Directive have not been utilized for additional products, or why they will not be under the Ecodesign Regulation, which replaces the Ecodesign Directive.[180] These exceptions underline the importance of clearly defining the relation between all relevant legal acts in order to prevent double regulation and inconsistencies.

Moreover, these exceptions give reason to reflect on possible alternatives to the product-specific life-cycle approach taken in the Batteries Regulation. The above-mentioned examples show that batteries could be and currently are already governed not only as products but also as components of the products in which they are placed. An alternative to the approach taken could have been to regulate all design aspects or even the battery sector as a whole under the Ecodesign Regulation.[181] The latter aims

[176] Harper et al., n. 42 above, p. 77; Thompson et al., n. 42 above, p. 7589.
[177] Lotz et al., n. 151 above, p. 13.
[178] Batteries Regulation, n. 13 above, Recital 42.
[179] Ibid., Recital 37.
[180] N. 154 above. See also Barkhausen et al., n. 22 above, p. 4.
[181] See also Van Tichelen, Mulder & Durand, n. 141 above, pp. 50–1, 56; Hill et al., n. 10 above, p. 169; European Commission, n. 7 above, pp. 62–3.

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to set ecodesign requirements for almost all physical goods on the EU market to improve their circularity and sustainability, and includes similar provisions and instruments, such as the product passport.[182] The suggestion to regulate all substances used in batteries under the REACH Regulation should also be mentioned here.[183] This discussion shows that governing the entire life cycle of a product can be approached from different perspectives.

Following these alternatives would mean that the entire battery life cycle would no longer be regulated under a single legal instrument, and life-cycle thinking might not be explicitly reflected in the legislative structure. However, this does not necessarily imply that the life cycle of batteries could not be sufficiently considered in an integrated way, even if regulated across multiple legal acts. The same applies to the interaction within the legal framework governing the life cycle of batteries, although new or different questions on interaction and coordination are likely to arise with each change in legislative structure. In short, further research is needed before endorsing the approach of the Batteries Regulation as a guideline for other products or sectors.

4. Conclusion

To create a circular and sustainable battery value chain, the EU has recently adopted the Batteries Regulation. This article shows that many of the barriers and incentives for the transition towards a circular battery value chain identified in the literature and interviews with stakeholders in the Netherlands have been addressed or incorporated in the Batteries Regulation. Notably, several provisions have been introduced to enable lifetime-extending or second-life operations for batteries and to incorporate a life-cycle thinking approach.

However, this article revealed some remaining challenges in the extent to which the Batteries Regulation is fit for purpose in achieving CE objectives. Firstly, the challenges associated with implementation of the Regulation should not be overlooked, as these will be important for its actual contribution to realizing CE objectives. Secondly, the Regulation could go further by encouraging higher value retention strategies. The focus on repair could be increased and consideration could be given to better address the reduction of placing on the market of certain batteries, such as those in disposable products. Thirdly, to further unlock synergies and avoid overlaps and inconsistencies, close attention should be paid to the interaction and interlinkages that exist not only between the life-cycle stages, but also within the entire legal framework governing the life cycle of batteries. Similarly, the interaction between circularity strategies must be considered, as potential negative trade-offs and conflicting objectives may arise. For example, there could be tensions between recycling or recycled content requirements and those aiming at lifetime-extending or second-life operations. Although, in principle, the waste hierarchy should be

[182] Ecodesign Regulation, n. 154 above; Batteries Regulation, n. 13 above, Recitals 37, 126; Arts 9(3), 78(a).

[183] See Section 2.1.

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adhered to, it is important to take into consideration that a higher value retention strategy may not necessarily have a lower environmental impact. In these cases, a derogation from the waste hierarchy is justified, which is in line with the fact that the aim of achieving circularity should be seen as a means to contribute to the EU's ambition to achieve a sustainable and climate-neutral economy. Nevertheless, in some cases this ambition might require difficult policy decisions to be made. Finally, the interaction within the legal framework on batteries requires continuous research to answer the question whether the product-specific life-cycle structure of the Batteries Regulation should be followed for other products, or whether alternative perspectives for approaching the legal framework could be preferred in the light of the CE transition.

Altogether, the identified challenges underline the importance of critically monitoring the implementation and further development of the Batteries Regulation to ensure its contribution to the transition towards a more circular batteries chain. The same applies to the legal framework on batteries as a whole, particularly in the light of recent developments such as the Clean Industrial Deal, including the announced adoption of a new Circular Economy Act.

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