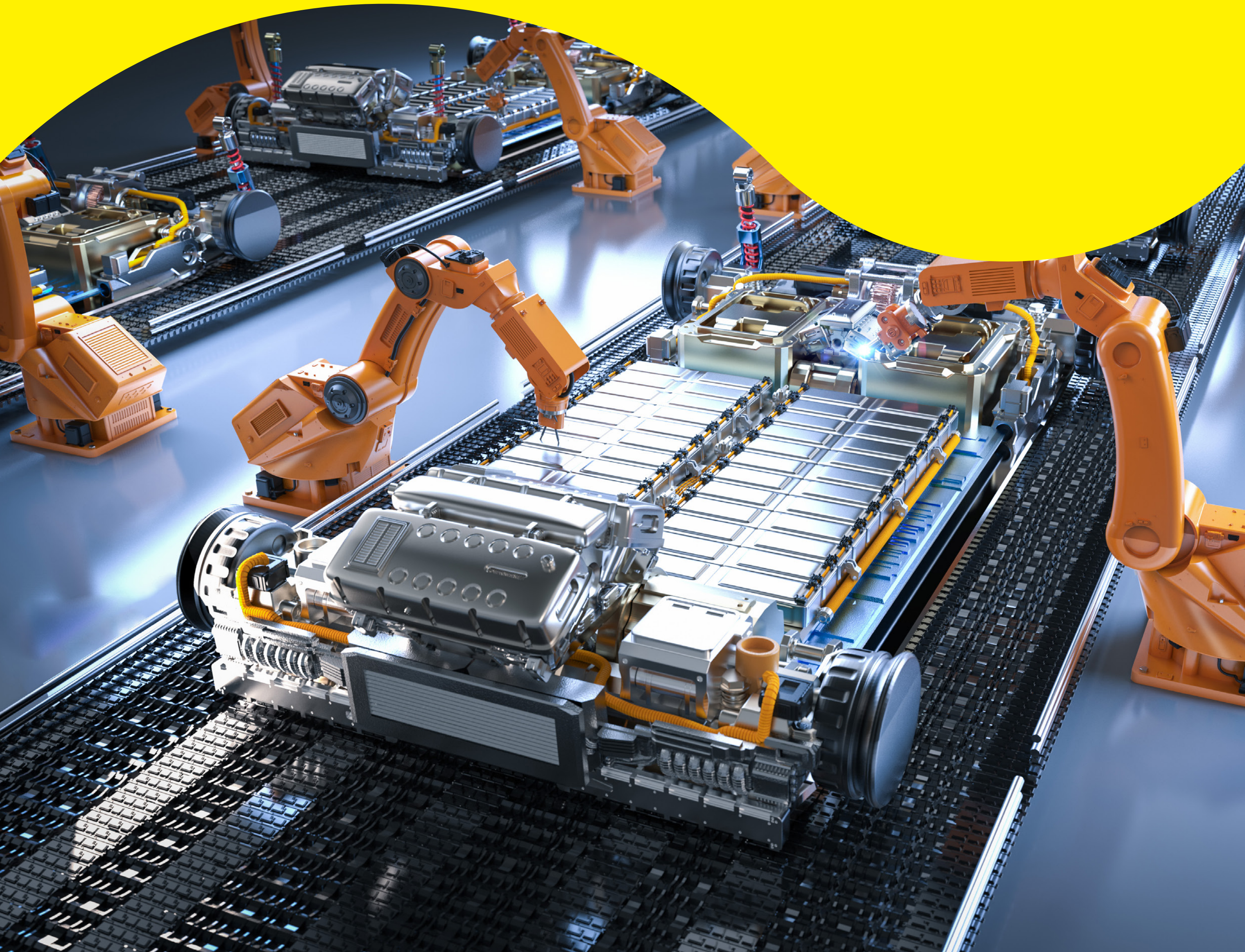
REPORT

Secondary Batteries Reuse, Repurpose, Recycle

June 2025



Acknowledgements

Standards Australia extends its gratitude to the members of the Secondary Batteries – Reuse Repurpose Recycle Advisory Group for their invaluable insights and guidance throughout this project. Their expertise has been instrumental in shaping our approach and ensuring the relevance and applicability of the recommendations developed in this report. The views presented in this report are based on input from the Advisory Group discussions, but it does not necessarily represent the views of any individual member of the Advisory Group.

We also wish to express our sincere appreciation to the Department of Finance for their generous funding support, which has been crucial in advancing this work. Furthermore, we acknowledge the ongoing assistance and collaboration provided by the Department of Industry, Science, and Resources. Their partnership has been vital in driving the project forward and achieving its goals. This collective effort exemplifies the power of collaboration.

ABOUT STANDARDS AUSTRALIA

Standards Australia is Australia's peak non-government, not-for-profit standards organisation. We work with Australian industry, government, academia, consumer groups, and the community to help address the challenges and opportunities facing the nation. Standards Australia represents Australia at the ISO and the International Electrotechnical Commission (IEC) and specialises in the development and adoption of internationally aligned standards.

Standards Australia's vision is to be a global leader in trusted solutions that improve life – today and tomorrow. This vision has taken on renewed importance as we grapple with emerging technologies that are transformative and developing at a rate that outpaces regulation and legislation. We work with a diverse group of stakeholders nationally and internationally to act on the opportunities and challenges posed by these technologies including quantum computing, smart cities, digital twin, the metaverse, and artificial intelligence (AI).

Key Terms, Abbreviations and Acronyms

ANSI	American National Standards Institute - Standards development organisation
Battery Cells	The fundamental building blocks of a battery system, where electrochemical reactions occur to store and release electrical energy.
Battery Modules	Battery modules are individual units within a battery system that consist of multiple interconnected battery cells arranged to achieve a desired voltage and capacity.
Battery Packs	Battery packs are the complete assemblies that include one or more battery modules, combined with additional components to form a fully functional unit ready for deployment in various applications.
BMS	Battery Management System
BESS	Battery Energy Storage System
CEN	European Committee for Standardization - Standards development organisation
Deployment	Safe and efficient integration of batteries into systems or devices, ensuring they meet performance and safety standards during installation, operation, and maintenance.
DUT	Device under test
E-mobility device	Devices including EVs, e-scooters, e-bikes, golf carts and personal mobility devices
EMS	Energy Management System
End user	Person who uses a product
ESS	Energy Storage Systems
EV	Electric Vehicle including cars, buses, trucks
IEC	International Electrotechnical Commission - Standards development organisation
IEEE	Institute of Electrical and Electronics Engineers - Standards development organisation
ISO	International Organization for Standardization - Standards development organisation
JSA	Japanese Standards Association - Standards development organisation
LEV	Light Electric Vehicle
NFPA	National Fire Protection Association
OEM	Original Equipment Manufacturer
Performance	Overall efficiency, capacity, cycle life, voltage stability, and response time of batteries in various applications and conditions.
Reliability	Ability of batteries to consistently perform as expected over their lifespan, including maintaining stable capacity, voltage, and performance under various conditions.
SA	Standards Australia - Standards development organisation
Safety	Measures and standards implemented to prevent risks such as overheating, short circuits, and fires, ensuring the safe operation and handling of batteries.
SAE	SAE International - Standards development organisation
Secondary Batteries	Rechargeable batteries
SDO	Standards Development Organisation
UL	Underwriters Laboratories - Standards development organisation

Executive Summary

As global demand for lithium-ion batteries rises, driven by electric vehicles, renewable energy storage, and consumer electronics, the need for sustainable recycling practices has become increasingly urgent. In Australia, challenges such as limited feedstock availability, safety concerns, and high operational costs hinder the recycling of lithium-ion batteries. Currently, all black mass produced from lithium-ion battery recycling is exported overseas for further refinement. With projections indicating that Australia could generate up to 137,000 tonnes of lithium battery waste annually by 2035, developing a domestic recycling industry is important.

Establishing a robust battery recycling industry in Australia presents significant economic opportunities, potentially creating a $3.1 billion industry within the next decade. Recycling could expand Australia's battery industry by reclaiming valuable materials and reducing reliance on raw imports. European estimates suggest mature recycling technologies could supply up to 77% of battery materials by 2050, and similar advancements in Australia could enhance the country's competitiveness, enabling the production of sustainable, high-quality batteries for both domestic and international markets.

The recent implementation of EU mandates for battery collection and recycling, which assigns clear responsibility to manufacturers for end-of-life management, highlights the urgent need for a comprehensive battery recycling infrastructure in Australia. By leveraging strengths in sustainability, recycling, and standards development, Australia could make its batteries more globally competitive. As the global supply of end-of-life electric vehicle batteries increases, the potential for remanufacturing and second-life applications will grow, further emphasising the need for an effective battery recycling strategy.

Standards play a crucial role in the evolving battery market, particularly in the used battery supply chain, where they establish best practices to ensure safety, promote global harmonisation, and maintain industry consistency. With the growing adoption of secondary batteries in electric vehicles, utilities, and home energy storage systems, standards are essential for governing the reuse, repurposing, and recycling of larger batteries. Standards provide guidelines for the safe evaluation, environmentally responsible sorting, grading, and application-specific requirements, while also addressing recycling, chemical identification, and storage safety to improve battery handling efficiency. In Australia, focusing on the development and adoption of these standards is vital for addressing battery recycling challenges and positioning the nation as a leader in sustainable battery management. This strategic approach will drive both environmental and economic benefits, supporting Australia's transition to a circular economy in the battery sector.

The report details 12 recommendations to strengthen Australia's used battery supply chain, including adopting international standards, modifying an existing standard, developing new standards for battery reuse and recycling, proposing new safety guidelines, and recommending industry-led initiatives.

Recommendations Summary

Recommendation 1: Update AS 4681:2000, *The Storage and Handling of Class 9 (Miscellaneous) Dangerous Goods and Articles,* to better address battery storage and handling

Standards Australia and industry stakeholders should collaborate to propose a revision of AS 4681:2000, *The Storage and Handling of Class 9 (Miscellaneous) Dangerous Goods and Articles,* to more effectively address the unique storage and handling requirements of batteries. However, this update is contingent upon the Australian government's first modifying the relevant Dangerous Goods Acts to reclassify batteries, reflecting their specific risks more accurately. Alternatively, a new, dedicated standard or best practice guide could be developed specifically for battery storage and handling, distinct from other miscellaneous dangerous goods.

Recommendation 2: Develop a standard to test suitability of used batteries for reuse, repurpose and recycling

Standards Australia and industry stakeholders should collaborate to propose to develop a new standard specifically focused on testing protocols for determining the suitability of used batteries for reuse, repurposing, or recycling. This standard should define clear testing methodologies and criteria for assessing the remaining capacity, safety, and performance of used batteries, establishing limits that will guide their optimal end-of-life pathways.

Recommendation 3: Adopt UL 1974 Evaluation for Repurposing or Remanufacturing Batteries

Standards Australia and industry stakeholders should collaborate to propose to adopt UL 1974, *Evaluation for Repurposing or Remanufacturing Batteries*, as a key standard for assessing the viability of repurposing or remanufacturing used batteries. This standard provides a comprehensive framework for evaluating the safety, performance, and reliability of secondary batteries when they are repurposed or remanufactured for new applications.

Recommendation 4: Adopt J17152 Battery Terminology

Standards Australia and industry stakeholders should collaborate to propose to adopt J17152, *Battery Terminology,* provided that its definitions are aligned with existing waste management terminology. This standard provides comprehensive terminology for various types of batteries and their related concepts, which can enhance clarity and consistency across the battery industry.

Recommendation 5: Develop a safety standard on discharging batteries prior to storage and disposal

Standards Australia and industry stakeholders should collaborate to develop a comprehensive safety standard or best practice guide that provides guidance for the discharge of batteries prior to their storage and disposal. This standard should outline procedures and safety measures for effectively discharging various types of batteries, including lithium-ion, lead-acid, and other chemistries, to ensure safe handling and minimise risks.

Recommendation 6: Adopt international standards for safe handling of batteries

Standards Australia and industry stakeholders should collaborate to propose to adopt international standard J2950_202006, *Recommended Practices for Shipping, Transport, and Handling of Automotive-Type Battery Systems - Lithium Ion,* to enhance the safety and management of battery handling in Australia. This standard should be tailored to local conditions and regulatory requirements to ensure comprehensive safety practices are applied across various battery types and applications.

Recommendation 7: Monitor standards under development for consideration of adoption

Standards Australia should implement a systematic approach to monitor and evaluate the standards currently under development, including IEC 62635 ED1, *Guidelines for end-of-life information provided by manufacturers and recyclers and for recyclability rate calculation of electrical and electronic equipment*, IEC 63338 ED1, *General guidance on reuse and repurposing of secondary cells and batteries*, and IEC 63330-1 ED1, *Repurposing of secondary batteries - Part 1: General requirements*, to assess their relevance and potential for adoption within Australia. Proactive monitoring should include regular reviews of draft documents, participation in relevant working groups, and engagement with international standardisation bodies to ensure timely and informed decisions regarding the adoption of these standards.

Recommendation 8: Develop standard on easy-to-recycle battery designs

Standards Australia and industry stakeholders should collaborate to develop and implement a standard, or guideline that provides guidance for easy-to-recycle battery designs. This standard or guideline should detail requirements for original equipment manufacturers to register and comply with labelling and design standards that facilitate efficient recycling processes. The standard should include specific criteria for design practices, labelling, and registration to ensure batteries are designed with end-of-life management in mind.

Recommendation 9: Australia to participate in key IEC battery working groups

Standards Australia should become either a participant or observer in IEC SC 21A's working groups PT 63330 and PT 63338. This involvement would enable Australia to actively contribute to the development of key standards—IEC 63330, *Repurposing of Secondary Batteries – Part 1: General Requirements* and IEC 63338, *General Guidance for Reuse of Secondary Cells and Batteries*. Such participation will ensure that Australia's interests are represented in these critical areas, supporting the safe, efficient, and sustainable management of secondary batteries.

Recommendation 10: Australia to participate in key IEC battery technical committee

Standards Australia should become either a participant or observer in IEC Technical Committee 35 (TC 35) on *Primary Cells and Batteries* and actively engage in Working Group JMT 18, which focuses on the safety of primary and secondary lithium batteries during transport. This involvement will allow Australia to contribute to and influence the development of international standards governing the safe transport of lithium batteries.

Recommendation 11: Circularise relevant battery standards to promote sustainability

Standards Australia should work to amend and circularise all relevant battery standards across industries to embed principles of the circular economy, thereby ensuring that sustainability is a core consideration in the design, production, use, and end-of-life management of products and materials.

Recommendation 12: Uniform guidance on battery disposal pathways across all sectors

Industry stakeholders should collaborate to establish comprehensive and uniform guidance on battery disposal pathways for all sectors of society, including household consumers, electric vehicle (EV) original equipment manufacturers, and reuse, repurpose, and remanufacture entities. This guidance should outline standardised procedures for the disposal, recycling, and management of batteries across various types and applications.

Contents

Introduction

As global demand for batteries, particularly lithium-ion batteries, continues to surge, driven by applications in electric vehicles, utilities, and consumer electronics, the need for effective recycling practices becomes more urgent. In Australia, the recycling of lithium-ion batteries faces significant challenges, including limited feedstock, safety concerns, and high costs. Currently, most of these batteries are sent overseas for processing, where they often end up in landfills. With projections indicating that Australia could generate 137,000 tonnes of lithium battery waste annually by 2035, the establishment of a domestic recycling industry is important, potentially creating an industry worth up to $3.1 billion within a decade[1].

Recycling presents a significant opportunity to expand Australia's battery industry, offering both economic and environmental benefits. European estimates suggest that mature and commercialised recycling technologies could supply up to 77% of battery materials by 2050[2], and similar advancements could position Australia as a competitive player on the global stage. Additionally, the recent EU mandates for stringent battery collection, recycling, and resource recovery targets underscore the importance of establishing robust recycling infrastructure[3]. Capitalising on Australia's strengths in sustainability, recycling, and standards will be essential to making Australian-made batteries viable in international markets. As the global supply of end-of-life electric vehicle batteries increases, driven by the transition to electric mobility, the potential for remanufacturing and second-life applications will also grow, further reinforcing the importance of an effective battery recycling strategy.

Standards play a critical role in the used battery supply chain by establishing best practices that can be integrated into regulations, ensuring safety, global harmonisation and promoting consistency across the industry.

Purpose

The purpose of this report was to set out findings from the Reuse Repurpose Recycle Advisory Group meetings and associated standards mapping research. This report aimed to:

- Highlight gaps for battery standards relating to reuse repurpose recycle of batteries.
- Provide recommendations which may include the adoption, revision and development of appropriate standards in Australia.

This project aimed to address gaps in technical standards and thereby work to eliminate trade barriers for Australian battery manufacturers, foster sustainable outcomes, and open access to both national and international markets. By focusing on standards related to the reuse, repurpose and recycling of batteries, this project seeks to promote sustainable, efficient, and safe management of secondary batteries throughout their lifecycle. This project will attempt to bridge any current gaps in standards by prioritising the adoption of international standards to foster harmonisation. Additionally, the project will prioritise Australian industry technological leadership in battery research and development across the reuse repurpose and recycle supply chain to ensure technical trade barriers are removed, foster an environment for innovation, ensure interoperability, build sustainability and address market preparedness.

The project's main objective was to undertake mapping research into Australian and international standards, particularly ISO and IEC, while also ascertaining any dominant standards globally. Additionally, the project will consider standards for various battery chemistries, primarily considering lithium-ion batteries, but will also leverage Australia's advancements in alternative

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1 Australian landscape for lithium ion battery recycling and reuse in 2020 - current status, gap analysis and industry perspectives. Produced for the Future Battery Industries CRC. (2023).
2 Metals for Clean Energy: Pathways to solving Europe's raw materials challenge. Gregoir et al., (2022).
3 National Battery Strategy. Leading the charge towards a competitive and diverse Australian battery industry. Department of Industry Science and Resources, Australian Government (2024).

battery technologies if relevant to broaden our reuse repurpose recycle options and open international market opportunities.

Note that the report was based on input from the Advisory Group, but it does not necessarily represent the views of any individual member of the Advisory Group.

Scope

The objective of this project is to identify existing gaps in Australian standards related to the reuse, repurpose, and recycling of secondary batteries, while broadly considering primary battery recycling.

The project aims to promote sustainable, efficient, and safe management of secondary batteries throughout their lifecycle, from reuse to refurbishment for repurposing and end-of-life recycling.

The scope of this project excludes manufacturing standards, battery performance standards, policy and regulatory frameworks, and non-battery energy storage solutions.

Standards Australia

Standards Australia is Australia's peak, independent, non-governmental, not-for-profit standards organisation. Standards Australia is Australia's representative of the ISO and IEC.

Standards Australia facilitates the development and adoption of internationally aligned standards in Australia. This is achieved through:

- Partnering in ISO and IEC standards development.
- Adoption of international standards, or regional standards where international standards do not exist.
- Creation and development of new standards where there are gaps in the international landscape or Australia has specific requirements.
- Empowering other organisations/bodies to develop standards content.

Standards Australia is not responsible for enforcing regulations, mandating standards, or certifying conformance with standards.

Advisory Group

There are various stakeholders working to understand the secondary battery landscape.
To ensure that the recommendations put forward in this report are well-considered and comprehensive, it was important to bring together a group of stakeholders that understand the impacts of secondary battery reuse repurpose and recycle and can advise Standards Australia on the industry standardisation needs as a result.

The Advisory Group, representing the stakeholder engagement component of the project, was established to review and provide advice on secondary battery standards (Appendix 1). The group used its expertise to shape the development of the standards mapping research, analyse the gaps and opportunities, and identify a strategy to address them.

Advisory Group members involved in this project have relevant expertise in the project scope, standards development, industry, academia, and/or government policy and regulation. Their collective knowledge and insights were crucial in ensuring that the standards pathway is robust, relevant, and effective in addressing the needs of the secondary battery sector. The views represented in this report are based on input from the Advisory Group meetings, but do not represent the views of any individual member of the Advisory Group.

Role of Standards Australia in National and International Standards Development

Standards Australia develops standards that deliver a net benefit to the Australian community. Our processes are designed to ensure that standardisation in Australia remains robust, promotes economic efficiency, and supports consumer safety.

Standards Australia is committed to aligning with Australia's international obligations under the WTO Technical Barriers to Trade Agreement. This means using relevant international standards, guides, or recommendations as a basis for regulations, unless a relevant international standard does not exist, or the international standard is not appropriate to fulfill the policy objectives. For example, due to climatic or geographical differences. As Australia's representative at the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC), Standards Australia specialises in the development and adoption of internationally aligned standards in Australia. We facilitate technical committees of Australian experts who provide expertise to help shape international standards, ensuring Australia's interests are represented globally. Our contributions are made with the view that the international standard will be used in Australia. In the absence of an International Standard, Standards Australia looks to relevant regional standards for adoption.

At a regional level, harmonisation of Australian and New Zealand standards is critically important. Australia and New Zealand are close trading partners with a common economic market and strong trade flows. The Trans-Tasman Mutual Recognition Act supports the harmonisation of standards in Australia and New Zealand by promoting bilateral integration and economic convergence. Standards Australia and Standards New Zealand work together to deliver joint standards appropriate for our economies across a range of sectors, including construction, consumer goods and electrical equipment. The identification of joint initiatives is a priority for Standards Australia, and we will continue to work with Standards New Zealand and relevant stakeholders to ensure harmonisation.

In some cases, relevant international standards do not exist, or are inappropriate for the Australian context. When this occurs, it may be necessary to develop an Australian Standard. Standards Australia has established processes for the development of Australian Standards to ensure all relevant impacts are considered. Proposals for the development of new standards are assessed under strict criteria, with consideration for:

- Potential impacts on competition and innovation
- Potential economic impacts across various domestic sectors
- Potential impacts on international alignment and global markets

This assessment is used as part of the evaluation process to determine whether appropriate international standards are available for adoption, or whether an Australian Standard should be developed.

A proposal must be submitted to Standards Australia to adopt an international standard, to revise or amend an existing standard, or to develop a new standard. A proposal can be submitted by any member of the public and is reviewed on four key criteria: evidence that there is a need for the work, a robust scope, a well-defined net benefit case and comprehensive stakeholder support, considering many different stakeholders interest categories.

Proposals that meet all key quality criteria will be assessed and resourced monthly. Once a proposal is approved, generally, if a proposal is received to revise/amend an existing standard, the project will be assigned to the technical committee that initially developed the standard. Similarly, if a proposal is approved to adopt international standard, the adoption(s) will be facilitated by the Australian technical committee that mirrors the international technical committee. For a proposal to develop a new standard, Standards Australia will ultimately decide (in consultation with the proponent and relevant stakeholders) on which technical committee the project will be assigned to, or if a new technical committee is required.

In 2023, Standards Australia implemented alternate standards development pathways to accelerate standards development efforts in new and emerging areas of endeavour where traditional models of standards development may not be fit for purpose. A major pillar of the alternate standards development pathways is the establishment of 'Project Committees', which may be formed to develop an Australian Standard under the alternative path or where technical specifications or handbooks are desired, but no technical committee exists. Project Committees are not formally constituted but aim to engage a broad group of stakeholders.

In addition to standards, Standards Australia also publishes other types of documents such as handbooks and technical specifications. There are instances where a normative or informative technical document is required, and traditional standardisation processes may not deliver the optimal solution. These are referred to as 'lower consensus solutions' due to the lower degree of consensus and consultation required to publish such documents, as compared to Australian Standards. The initiation of a new document such as a handbook or technical specification is still subject to a proposal being submitted to and approved by Standards Australia.

Benefits of International Standards Adoption

Adopting international standards is vital for Australia to establish a competitive secondary battery manufacturing industry. These standards ensure consistent quality, reliability, and safety, enhancing consumer trust and minimising risks such as thermal runaway, short circuits, and electrolyte leaks. They align Australian products with international requirements, facilitating easier market entry, reducing trade barriers, and simplifying the approval process. By incorporating the latest technological advancements and best practices, these standards support innovation and provide a clear roadmap for research and development, allowing Australian manufacturers to match global benchmarks. Operationally, standards streamline processes, reduce costs, and optimise supply chains through guidelines and efficient resource use.

Economically, compliance with international standards can attract foreign investment, support job creation, and integrate Australian manufacturers into global supply chains. Environmentally, international adoption of standards can promote sustainable manufacturing practices and provide guidelines for responsible sourcing, reuse, repurpose and recycling of batteries, by supporting circular economy principles. Additionally, international standards ensure the interoperability of Australian batteries with various devices and systems, enhancing their appeal and usability in global markets. Overall, adopting international standards will strengthen Australia's reputation for producing high-quality, reliable batteries, aligned with national and international sustainability initiatives.

Standards Mapping Research

Australia and International Standards Research

As Australia works towards an energy transition that relies heavily on secondary batteries, the Australian standards landscape for battery reuse, repurpose and recycling, is insufficient. Over recent years, Australia has been actively adopting international standards, often integrating local modifications to better align with domestic conditions and industry needs. Nevertheless, the standards related to reuse repurpose and recycle in the global environment have also shown weakness when benchmarked against the used secondary battery supply chain.

It is recommended that adopting international standards reflects Australia's commitment to maintaining high-quality standards and being an active participant in the global supply chain, while adapting to the unique requirements of local markets. Australia has a notable history of developing bespoke battery standards that address specific national needs, such as environmental considerations, safety protocols, and performance metrics suited to our local context.

This strategy enables existing and potential participants in the battery industry to efficiently navigate the global supply chain. By adhering to international standards established in markets where global product importers and designers operate, Australia gains a valuable resource on its path toward Net Zero goals and the realisation of a circular economy.

As Australia advances in secondary battery reuse, repurpose and recycling, we have an opportunity to contribute Australian practices and innovations to global standards development, supporting the adoption of advanced technologies on a global scale. A collaborative approach within the worldwide scientific community expedites a streamlined and efficient transition toward circular economy solutions across diverse geographical contexts, benefiting all supply chain participants.

In 2021, Australia achieved a 99% recycling rate for lead acid batteries[4]. This success can serve as a model for developing reuse, repurpose and recycling standards for other battery chemistries, such as lithium-ion, lithium iron phosphate and nickel-cadmium.

Standards Mapping Overview

To gain insights into the standards landscape, both here in Australia and globally, mapping research was conducted to compile existing relevant standards pertaining to the reuse, repurpose and recycling of secondary batteries. The table below is the scope of this standards mapping. The purpose of this study was to help the Advisory Group identify gaps in standards in the following areas of the used secondary battery supply chain. The research also helps guide recommendations which may include the adoption of recognised international standards and development of local standards in Australia.

No. of Standards	81 (including 24 standards under development)
Regions Covered	Australia, International, United States, Japan, Korea
Standards Development Organisations (SDOs)	Standards Australia (SA) International Organization for Standardization (ISO) International Electrotechnical Commission (IEC) UL Solutions (UL) Institute of Electrical and Electronics Engineers (IEEE) National Fire Protection Association (NFPA of the U.S.) United Nations / International Air Transport Association (UN/IATA) SAE International (SAE) Japanese Industrial Standards (JIC) Korean Agency for Technology and Standards (KATS) (for the purpose of this study, Korean Standards Association (KSA) and Korean Battery Industry Association (KBIA) are categorised as a single SDO Standards New Zealand
Areas Covered	Collection & transportation, sorting & testing, reuse & repurpose, disassembly & material recovery, recycling, analysis, general life cycle, battery labelling.

Table 1: Standards Mapping Scope

4 DISR (2024), *National Battery Strategy*, https://www.industry.gov.au/sites/default/files/2024-05/national-battery-strategy.pdf

The Standards Development Organisations (SDOs) considered in this report were chosen based on Australia's existing bilateral agreements, international trade partnerships, technological advancements, and recommendations from the Advisory Group. While the mapping is not exhaustive, it is tailored to meet the specific needs and objectives of the project.

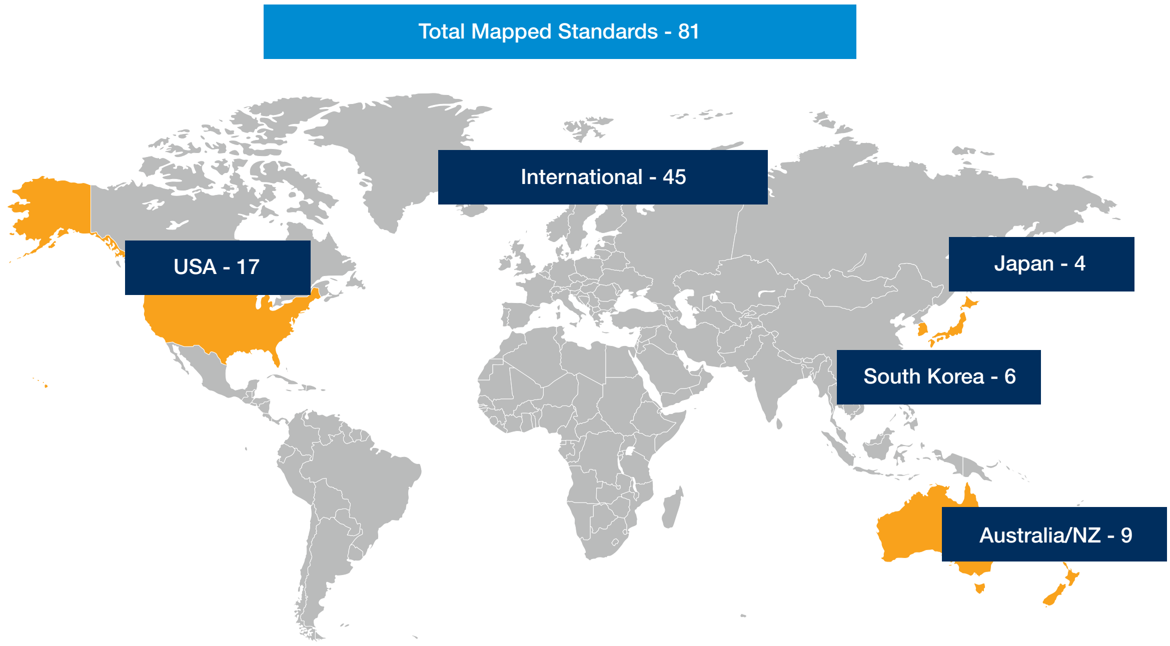


Figure 1: Number of standards mapped, by region

A total of 81 standards from 13 different standard development organisations were identified in the mapping research. Of these, 46 standards were published by international standard development organisations, such as ISO, IEC and SAE, while 18 were published by organisations in the US, like IEEE and UL. Ten standards are mapped from Australia and New Zealand.

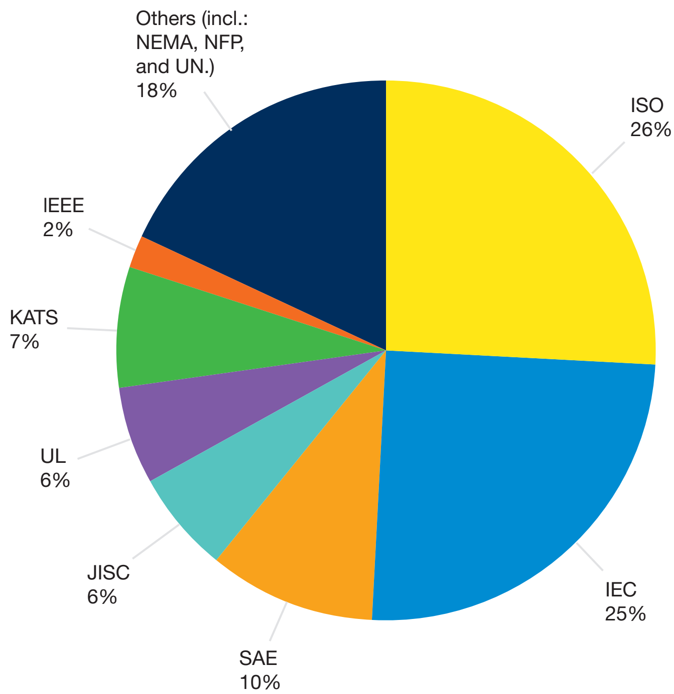


Figure 2: Percentage of standards mapped, by standard development organisations.

Mapped standards are further categorised under eight supply chain stages. This categorisation is to facilitate better understanding and analysis of the standards landscape.

This research identified 28 standards related to analysis (of which 15 are currently under development), followed by 24 related to collection and transportation, 23 sorting and testing, 21 disassembly and material recovery, and 17 on general life cycle.

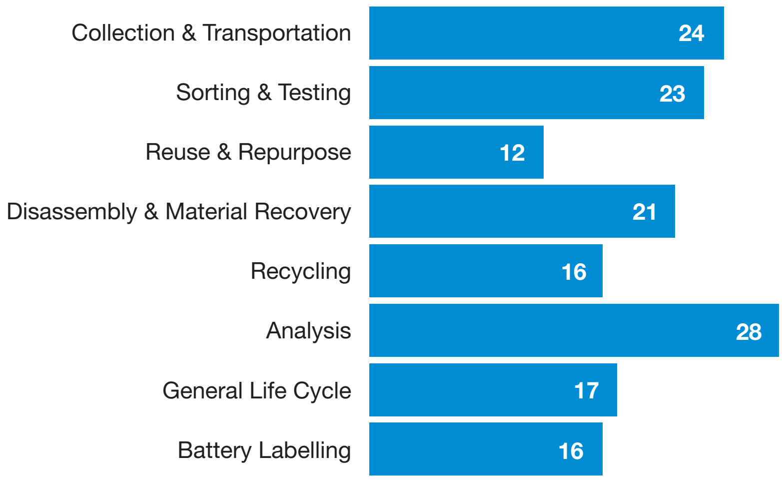


Figure 3: No. of standards mapped, by supply chain category

Standards Research Insights

Key Standards

Battery markets are evolving rapidly, driven by the widespread adoption of secondary batteries in electric vehicles, utilities, and home energy storage systems. This tremendous growth has brought increased attention to standards focused on the reuse and repurposing of larger batteries, the storage of new and used lithium-ion batteries, and best practices for battery labelling.

Below are some of the key standards addressing reusing and repurposing and recycling of secondary batteries:

- **UL 1974, *Evaluation for Repurposing or Remanufacturing Batteries*,** specifically addressing the evaluation and repurposing of batteries. It ensures the safe handling and environmentally sound practices for used electric vehicle (EV) batteries, covering sorting, grading, and application-specific requirements for repurposed battery packs, modules, cells, and electrochemical capacitors.
- **IEC 63338, *General guidance on reuse and repurposing of secondary cells and batteries,*** applies to the reuse and repurposing of secondary lithium-ion and nickel-metal hydride cells and batteries after extraction from the application for which they were first placed on the market (hereafter "relevant cells and batteries"). It does not permit reuse or repurposing of single cells or cell assemblies if battery lifetime traceability data are not recorded. Swappable batteries such as those used in e-scooters are removed and installed by the user (such as for charging) without conducting a safety assessment (such as battery lifetime traceability data assessment) as part of intended use, which is not considered reuse or repurposing. This document does not cover system component

reuse and repurposing. The original manufacturer can be contacted to confirm suitability of components for reuse and repurposing.

The primary purpose of this standard is to provide basic guidance on the environmental aspects of reuse and repurposing of relevant cells and batteries; basic guidance on safety risks for the reuse and repurposing of relevant cells and batteries; basic guidance on original manufacturer warning notice on the applicability of a product for reuse or repurposing; and useful information regarding reuse and repurposing and relevant cell and battery regulations and standards to interested parties.

- **J2974_201902,** ***Technical Information Report on Automotive Battery Recycling,*** focuses on the language used to describe batteries at the end of battery or vehicle life as batteries are transitioned to the recycler, dismantler, or other third party. This document also provides a compilation of current recycling technologies and flow sheets, and their application to different battery chemistries at the end of battery life. At the time of document authorship, the technical information cited is most applicable to lithium-ion battery type rechargeable energy storage systems (RESS), but the language used is not to be limited by chemistry of the battery systems and is generally applicable to other rechargeable energy storage systems.
- **J2984_202109,** ***Chemical Identification of Transportation Batteries for Recycling,*** aims to facilitate efficient recycling of rechargeable battery systems used in transportation applications with a voltage of 12 V or higher. The secondary battery applications include propulsion, starting, lighting, ignition, and powering. Non-rechargeable batteries, electronics batteries, and telecom/utility batteries are not covered by this specification, but they can still adopt the proposed format if required.
- **J3303,** ***Lithium and Lithium-Ion Cell and Battery Containment Performance Recommended Practice for Storage,*** prescribes test conditions to quantify the effectiveness of micro-containment devices for containing thermal runaway hazards of lithium/lithium-ion cells, batteries, and equipment during storage. These hazards can result from the failure of a cell within the container. Considering different storage environments (such as indoors or outdoors), the standard assesses hazards individually, allowing for customised performance criteria based on the specific storage location. This practice is especially crucial due to the growing adoption of lithium-ion batteries in automotive applications, where safe storage is paramount.
- **J2936_201212,** ***SAE Electrical Energy Storage Device Labelling Recommended Practice,*** provides labelling guidelines for electrical energy storage devices. These guidelines apply at all levels of component, subsystem, and system architectures. It outlines the necessary content, placement, and durability criteria for specific units across the entire life cycle of energy storage products, from creation to reclamation. Essentially, they promote consistent and transparent labelling practices for energy storage systems.
- **J3071_201604,** ***Automotive Battery Recycling Identification and Cross Contamination Prevention,*** presents a chemistry identification system intended to support the proper and efficient recycling of rechargeable battery systems used in transportation applications with a maximum voltage greater than 12V (including (Starter, Lights, Ignition) SLI -batteries). Applicable to all types of secondary battery systems, this standard accentuates the importance to develop a system that can assist the used battery sorting at recycling facilities.

Standards Under Development

Of the 81 standards identified and mapped through the research, 24 are currently under development, accounting for nearly 30% of the total (Figure 4). These emerging standards are being developed by various organisations, including ISO (17), IEC (4), SAE International (2), and KTC (1), and cover the following categories:

- Analysis of lithium alloy
- Reuse and repurpose
- Collection and transportation
- Analysis of lithium in alloys
- Battery labelling

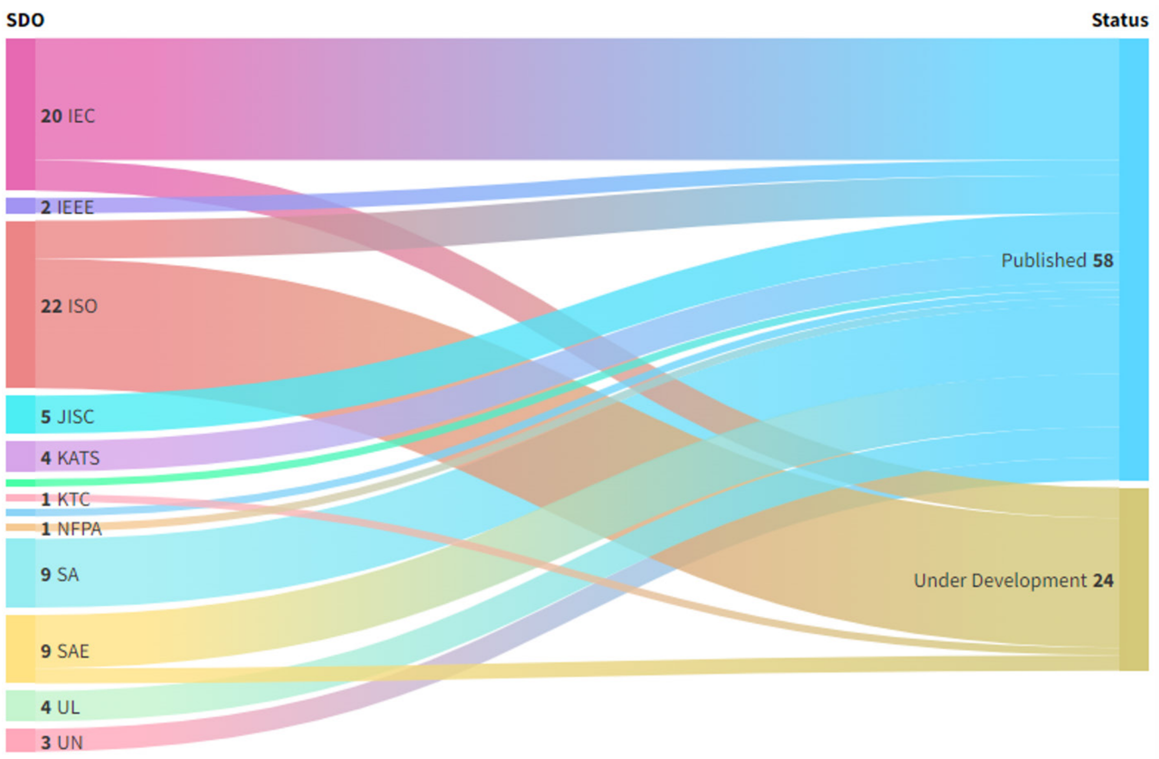


Figure 4: Standards under development by standard development organisations

Key standards under development

- **ISO/AWI 16423, *Lithium hydroxide monohydrate — Determination of impurities — ICP-OES method,*** provides a methodology for the quantification of the following trace elements in the lithium hydroxide monohydrate matrix: calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), aluminium (Al), boron (B), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), nickel (Ni), lead (Pb), zinc (Zn), sulphur (expressed as SO4-2) and silicon (Si).
- **ISO/AWI 11045-1, *Methods for chemical analysis of lithium salts Part 1: Quantitative determination of lithium hydroxide and lithium carbonate content in lithium hydroxide monohydrate — Potentiometric titration method,*** includes a method for the quantitative determination of lithium hydroxide (LiOH) and lithium carbonate (Li2CO3) in LiOH monohydrate (LHM). This method of determination is not suitable for LiOH anhydrous (LHA) because it rapidly absorbs CO2 from the atmosphere. This method utilises a potentiometric probe with an automatic titrator to measure both LiOH and Li2CO3 in the

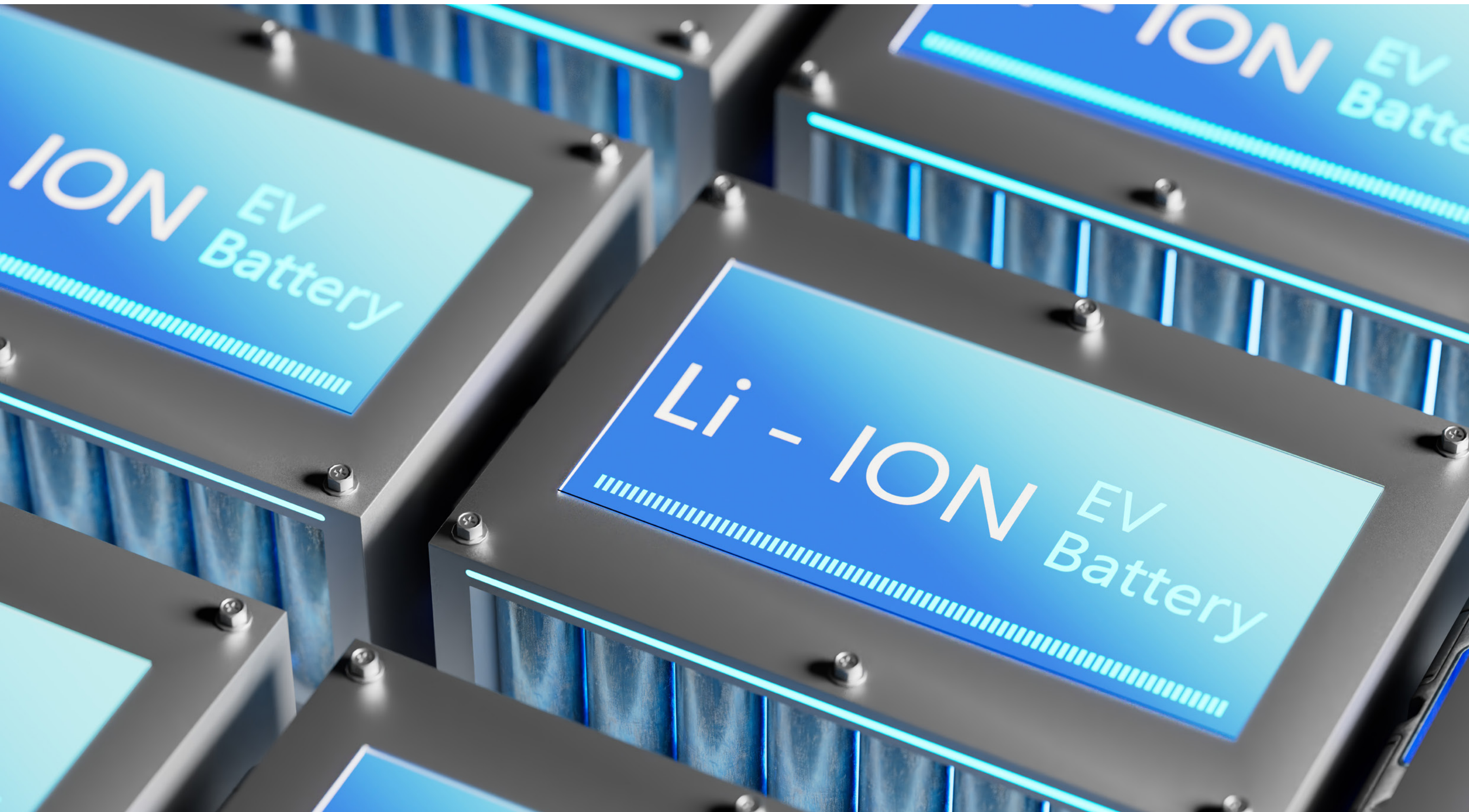
test solution. This approach is more efficient and precise than colorimetric approaches that rely mainly on manual operation and visual inspection.

- **IEC TR 62933-2-201 ED1,** ***Review of testing for BESS in consideration of implementing repurpose and reuse batteries,*** provides a review of testing for Battery Energy Storage Systems (BESS) in consideration of implementing repurpose and reuse batteries. It covers safety aspects, original manufacturer warnings, and relevant regulations.
- **J2997,** (WIP) ***Standards for Battery secondary use*** caters to a testing and identity regimen to define batteries for variable safe reuse.

  This standard under development is expected to use the existing or in process standards such as Transportation, Labelling and State of Health (SoH). This standard would offer a safe and reliable use adding on to these reference standards the required information.

  This is potentially for the SoH standards to help maintain the batteries in their best reuseable and compatible condition should provide for the best way to lower the overall lifetime cost of the batteries. Transportation standards would be necessary to provide for multiple location resources to repackage and have storage logistics. Labelling would also be necessary to authenticate the state of health and compatibility with traceability.
- **KC 10031,** ***Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium batteries to repurpose used lithium batteries***

  This standard applies to inspection and test methods for reusable batteries/modules, battery packs, cells, and cell blocks. Checks are required to on the open circuit voltage (OCV), insulation and capacity. The standard also requires AC. internal resistance, DC. internal resistance and a current leakage test. The battery system is checked for overcurrent, overvoltage and overtemperature protection, as required in KC 62619.



Standards Comparative Analysis & Insights

The mapped standards are categorised according to the stages of the used battery supply chain, as shown in Figure 5. Detailed information on the standards within each category is provided in Tables 2-8, with a clear distinction between Australian and international standards. This segmentation helps to identify gaps in the current standards landscape.

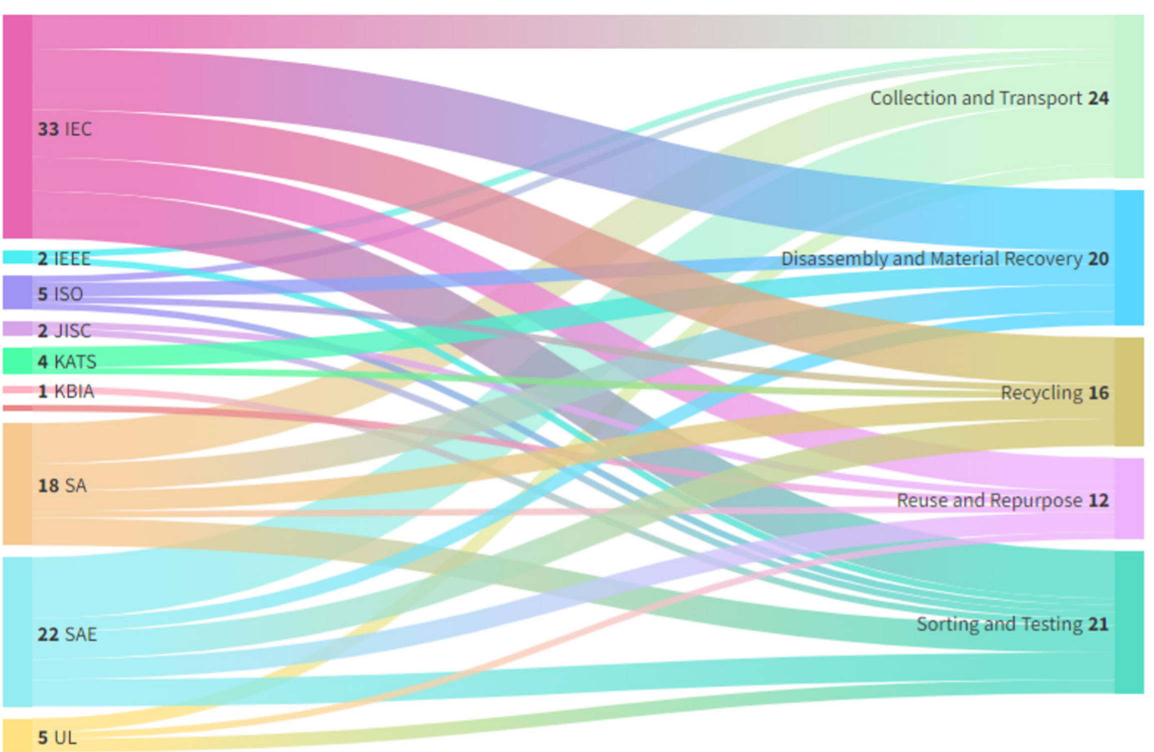


Figure 5: Used Battery Supply Chain Standards, by standard development organisations

Collection and Transportation Standards

The Australian Standards across collection and transportation tend to focus on the general management and safe handling of hazardous substances, as well as the management of electrical and electronic equipment for reuse or recycling (Table 2). In contrast, the international standards are more specific to batteries, with detailed safety requirements for various types or secondary batteries and best practice for lithium-ion batteries storage, transport and recycling.

These observations suggest that while Australia has established some general standards for hazardous materials management, there is a significant need to develop or adopt more specialised standards for the battery industry, particularly in the areas of collection and transportation, to keep pace with international best practices.

Australian Standards
AS 3780:2023, *The storage and handling of corrosive substances*
AS 5377:2022, *Management of electrical and electronic equipment for re-use or recycling*
AS/NZS 3833:2007, *The storage and handling of mixed classes of dangerous goods, in packages and intermediate bulk containers*
AS/NZS 4681:2000, *The storage and handling of Class 9 (miscellaneous) dangerous goods and articles*
International Standards
IEC 62485-1:2015, *Safety requirements for secondary batteries and battery installations - Part 1: General safety information*
IEC 62485-2:2010, *Safety requirements for secondary batteries and battery installations - Part 2: Stationary batteries*
IEC 62485-3:2014, *Safety requirements for secondary batteries and battery installations - Part 3: Traction batteries*
ISO/AWI 18006-2, *Electrically propelled road vehicles — Battery information — Part 2: End of life*
J1715/2_202108, *Battery Terminology*
J2936_201212, *SAE Electrical Energy Storage Device Labelling Recommended Practice*
J2950_202006, *Recommended Practices for Shipping Transport and Handling of Automotive-Type Battery System - Lithium Ion*
J3071_201604, *Automotive Battery Recycling Identification and Cross Contamination Prevention*
J3235_202303, *Best Practices for Storage of Lithium-Ion Batteries*
J3303, *Lithium and Lithium-Ion Cell and Battery Containment Performance Recommended Practice for Storage*
UL 2054, *Household and Commercial Batteries*
UL 9540A, *Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*

Table 2: Collection and Transportation Standards

Sorting and Testing

Australian standards focusing on sorting and testing are primarily concentrated on the storage and handling of dangerous goods. However, there is a noticeable lack of standards specifically targeting the unique requirements of used secondary batteries (Table 3). This highlights a potential area for development, especially given the rapid growth of battery use and the importance of tailored safety standards.

The international standards, such as those from IEC, IEEE, and SAE, provide a more targeted approach to the battery lifecycle, including the reuse, repurposing, and end-of-life management of batteries (Table 3). The global standards bodies are better addressing the entire battery lifecycle, including safety during transportation and end-of-life management.

Given the comprehensive nature of international standards, there is an opportunity for Australia to align its standards with these global practices.

Australian Standards
AS 3780:2023, *The storage and handling of corrosive substances*
AS/NZS 3833:2007, *The storage and handling of mixed classes of dangerous goods, in packages and intermediate bulk containers*
AS/NZS 4681:2000, *The storage and handling of Class 9 (miscellaneous) dangerous goods and articles*
International Standards
IEC 63333:2023, *General method for assessing the proportion of reused components in products*
IEC 62309, *Dependability of products containing reused parts - Requirements for functionality and tests*
IEEE 1679-2020, *IEEE Recommended Practice For The Characterization And Evaluation Of Energy Storage Technologies In Stationary Applications*
ISO/AWI 18006-2, *Electrically propelled road vehicles — Battery information — Part 2: End of life*
J1715/2_202108, *Battery Terminology*
J2936_201212, *SAE Electrical Energy Storage Device Labelling Recommended Practice*
J2950_202006, *Recommended Practices for Shipping Transport and Handling of Automotive-Type Battery System - Lithium Ion*
J3071_201604, *Automotive Battery Recycling Identification and Cross Contamination Prevention*
UL 9540A, *Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*

Table 3: Sorting and Testing Standards

Reuse and Repurpose

The number of standards currently under development highlights the rapidly developing nature of the battery reuse and repurposing sector (Table 4). These emerging standards are crucial to address technical, safety, and environmental challenges associated with the demands or reuse and repurpose of batteries.

The existing international standards emphasise the importance of stringent environmental and safety criteria, general guidance for reuse and repurposing, quality management and evaluation, and labelling practices. These standards facilitate harmonisation of practices and reduce barriers to trade by creating a level playing field for manufactures and recyclers worldwide.

Notably, there are no equivalent Australian standards addressing the reuse and repurposing of batteries, leaving a significant gap in the domestic standards landscape. This highlights the need for Australia to develop or adopt similar standards to ensure Australia can keep pace with global developments and maintain some competitiveness in the used battery sector.

International Standards
IEC TR 62933-2-201 ED1 (WIP), *Review of testing for BESS in consideration of implementing repurpose and reuse batteries*
IEC 62933-4-4:2023, *Electrical energy storage (EES) systems - Part 4-4: Environmental requirements for battery-based energy storage systems (BESS) with reused batteries*
IEC 63330-1 ED1 (WIP), *Repurposing of secondary batteries - Part 1: General requirements*
IEC 63338 ED1 (WIP), *General guidance on reuse and repurposing of secondary cells and batteries*
J1715/2_202108, *Battery Terminology*
J2936_201212 SAE, *Electrical Energy Storage Device Labelling Recommended Practice*
J2997 (WIP), *Standards for Battery secondary use*
JIS Q 9092: 2022, *Quality management systems — Battery reuse — Requirements*
KC 10031, *Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium batteries to repurpose used lithium batteries*
UL 1974 ANSI/CAN/UL, *Standard for Evaluation for Repurposing Batteries*

Table 4: Reuse and Repurpose Standards

Disassembly and Material Recovery

The Australian Standards across disassembly and material recovery provide a broad framework for the safe handling and storage of hazardous materials, but they lack specific guidelines tailored to the disassembly and material recovery of used batteries (Table 5).

The international standards address the disassembly and mechanical sample preparation of electrotechnical products, safety requirements for secondary cells and batteries, methodologies for determining the presence of specific substances in batteries, the functional safety of rechargeable energy storage systems, and provide end-of-life guidelines for electrically propelled road vehicles.

There is a noticeable gap in Australian Standards because the standards are more generalised and do not offer the same level of detail as the international standards, particularly in addressing the complexities of modern battery technologies. The Australian standards landscape presents an opportunity for the development of more specialised standards that cater to the disassembly and material recovery from used batteries.

Australian Standards
AS 3780:2023, *The storage and handling of corrosive substances*
AS 5377:2022, *Management of electrical and electronic equipment for re-use or recycling*
AS/NZS 3833:2007, *The storage and handling of mixed classes of dangerous goods, in packages and intermediate bulk containers*
AS/NZS 4681:2000, *The storage and handling of Class 9 (miscellaneous) dangerous goods and articles*
International Standards
IEC 62133-2, *Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications - Part 2: Lithium systems*
IEC 62321-1:2013, *Determination of certain substances in electrotechnical products - Part 1: Introduction and overview*
IEC 62321-2:2021, *Determination of certain substances in electrotechnical products - Part 2: Disassembly, disjointment and mechanical sample preparation*
IEC 62485-3:2014, *Safety requirements for secondary batteries and battery installations - Part 3: Traction batteries*
J1715/2_202108, *Battery Terminology*
J2936_201212, *SAE Electrical Energy Storage Device Labelling Recommended Practice*
ISO/TR 9968:2023, *Road vehicles — Functional safety — Application to generic rechargeable energy storage systems for new energy vehicle*
ISO/AWI 18006-2, *Electrically propelled road vehicles — Battery information — Part 2: End of life*

Table 5: Disassembly and Material Recovery Standards

Recycling

There is a noticeable absence of Australian standards specifically addressing the recycling of used batteries (Table 6). This gap suggests a need for Australia to develop or adopt international standards that provide comprehensive guidelines for end-of-life battery management, safety data sheet requirements, and recycling practices.

The current international standards offer guidelines for providing end-of-life information and calculating recyclability rates for electronic equipment. They detail safety data sheets for chemical products, which is critical for the safe handling and recycling of batteries. They also focus on chemical identification of transportation batteries and detail how to prevent cross-contamination during recycling. The standards also describe standardised terminology and labelling practices for batteries, while also emphasising the importance of standardised methods for calculating the recyclability rate of batteries.

The lack of dedicated Australian Standards in battery recycling presents an opportunity for the country to develop its own set of standards or to incorporate elements from international standards. Australia could benefit from implementing similar standards to ensure that the recycling of used batteries is carried out safely and efficiently.

International Standards
IEC TR 62635:2012, *Guidelines for end-of-life information provided by manufacturers and recyclers and for recyclability rate calculation of electrical and electronic equipment*
IEC 62635 ED1 (WIP), *Guidelines for end-of-life information provided by manufacturers and recyclers and for recyclability rate calculation of electrical and electronic equipment*
ISO 11014:2009, *Safety data sheet for chemical products — Content and order of sections*
J1715/2_202108, *Battery Terminology*
J2936_201212, *SAE Electrical Energy Storage Device Labelling Recommended Practice*
J2984_202109, *Chemical Identification of Transportation Batteries for Recycling*
J3071_201604, *Automotive Battery Recycling Identification and Cross Contamination Prevention*
KS C IEC/TR 62635, *Guidelines for calculating end-of-life (EoL) information and recyclability of electrical and electronic equipment provided by manufacturers and recyclers*

Table 6: Recycling Standards

Analysis

International standards related to batteries covering analysis are extensive, where they address chemical analysis methods, with a focus on lithium compounds, and technical information in recycling practices (Table 7). There are a number of emerging standards focussed on the determination of impurities and content in lithium salts and carbonates. These emerging standards indicate ongoing efforts to refine recycling methodologies and improve material recovery.

International standards provide a robust framework for the analysis, safety, and recycling of used batteries. There is a notable gap in Australian Standards specifically addressing the detailed chemical analysis and recycling practices for used batteries. While Australian Standards cover general storage and handling of dangerous goods, there is a lack of specific standards for the chemical analysis and recycling of used battery materials.

International Standards
IEC 62321-1:2013, *Determination of certain substances in electrotechnical products - Part 1: Introduction and overview*
IEC 62321-3-1:2013, *Determination of certain substances in electrotechnical products - Part 3-1: Screening - Lead, mercury, cadmium, total chromium and total bromine by X-ray fluorescence spectrometry*
IEC 62321-5:2013, *Determination of certain substances in electrotechnical products - Part 5: Cadmium, lead and chromium in polymers and electronics and cadmium and lead in metals by AAS, AFS, ICP-OES and ICP-MS*
ISO/AWI 12467-2, *Chemical analysis of lithium composite oxides - Part 2: Determination of trace elements*
ISO/CD 12467-1, *Chemical analysis of lithium composite oxides - Part 1: Determination of main components*
ISO/CD 10655, *Methods for analysis of lithium hexafluorophosphate — Determination of metal ions content by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES).*
ISO/AWI 24992, *Methods for analysis of lithium hexafluorophosphate — Determination of anions content by Ion Chromatography (IC)*
ISO 11014:2009, *Methods for analysis of lithium hexafluorophosphate — Determination of anions content by Ion Chromatography (IC)*
ISO 11014:2009, *Safety data sheet for chemical products — Content and order of sections*
J1715/2_202108, *Battery Terminology*
SPS-KBIA-20100-01-2039: 2014, *Cathode materials for use in lithium ion secondary batteries - Part 1: test method of chemical and physical properties*
J2984_202109, *Chemical Identification of Transportation Batteries for Recycling*
J2974_201902, *Technical Information Report on Automotive Battery Recycling*
J2936_201212, *SAE Electrical Energy Storage Device Labelling Recommended Practice*
ISO/AWI 24991, *Methods for chemical analysis of lithium concentrates- Determination of lithium oxide content — Flame atomic absorption spectrometry* (WIP)
ISO/AWI 16423, *Lithium hydroxide monohydrate — Determination of impurities — ICP-OES method* (WIP)
ISO/WD 16398, *Lithium chloride — Determination of impurities — ICP-OES method* (WIP)
ISO/AWI 12467-3, *Chemical analysis of lithium composite oxides Part 3: Determination of lithium carbonate and lithium hydroxide contents* (WIP)
ISO/WD 12403, *Lithium carbonate — determination of chloride content by potentiometry* (WIP)
ISO/WD 12386, *Lithium carbonate - Determination of metallic magnetic impurities by ICP-OES* (WIP)
ISO/WD 12380, *Lithium carbonate - Determination of insoluble particles in acid by gravimetry* (WIP)
ISO/WD 11757, *Lithium carbonate - Determination of elemental impurities by ICP-OES* (WIP)
ISO/AWI 11045-1, *Methods for chemical analysis of lithium salts Part 1: Quantitative determination of lithium hydroxide and lithium carbonate content in lithium hydroxide monohydrate — Potentiometric titration method* (WIP)
ISO/WD 10662, *Determination of main content of lithium carbonate-Potentiometric titration* (WIP)
ISO/CD 7819, *Lithium-Vocabulary* (WIP)

Table 7: Analysis Standards

Battery Labelling

Australian Standards, such as those for environmental labelling and declarations, provide valuable frameworks for communicating the environmental impact of batteries (Table 8). However, they do not offer as much detail on specific battery labelling practices compared to international standards. In contrast, the international standards offer detailed and specific guidance on battery labelling, including hazardous labels, recycling symbols, and detailed information on battery chemistry and safety. These standards help ensure that batteries are correctly identified and managed throughout their lifecycle, from manufacturing to disposal.

There is a clear opportunity for Australia to align more closely with international standards related to battery labelling. This alignment would improve consistency and effectiveness in battery management and recycling processes, facilitating better international trade and compliance with global best practices. Adopting detailed international labelling practices, such as those for hazardous materials and recycling symbols, would enhance safety and transparency.

Battery-specific labels should:

- Clearly identify components and hazardous substances.
- Emphasise safety precautions to prevent issues such as short-circuits, overheating, and improper storage.
- Provide clear disposal instructions, directing users to appropriate collection points or recycling facilities.
- Highlight the environmental impact of improper disposal.

Addressing these elements ensures that labels not only inform users but also promote safe and responsible handling and disposal practices for secondary batteries.

Australian Standards
AS 14025:2017, *Environmental labels and declarations - Type III environmental declarations - Principles and procedures (ISO 14025:2006, MOD)*
AS ISO 14020:2015, *Environmental labels and declarations - General principles*
AS/NZS 4681:2000, *The storage and handling of Class 9 (miscellaneous) dangerous goods and articles*
AS 60095.1 2022, *Lead-acid starter batteries, Part 1: General requirements and methods of test*
International Standards
UN 3481, *Lithium Battery Hazardous Label (Class 9)*
IEC 61429, *Marking of secondary cells and batteries with the international recycling symbol ISO 7000-1135*
ISO/AWI 18006-1, *Electrically propelled road vehicles — Battery information — Part 1: Labelling and QR/bar code for specification, safety and sustainability*
J1715/2_202108, *Battery Terminology*
J2936_201212, *SAE Electrical Energy Storage Device Labelling Recommended Practice*
JIS Z 7252, *Classification of chemicals based on "Globally Harmonized System of Classification and Labelling of Chemicals (GHS)"*
JIS Z 7253, *Hazard communication of chemicals based on GHS—Labelling and Safety Data Sheet (SDS)*
IEC 62902:2019, *Secondary cells and batteries - Marking symbols for identification of their chemistry*
AS/NZS 4681:2000, *The storage and handling of Class 9 (miscellaneous) dangerous goods and articles*

Table 8: Battery Labelling Standards

Industry Needs

This section draws on insights from four Advisory Group meetings facilitated by Standards Australia. It provides an overview of the current standards landscape and identifies future needs within the used battery supply chain, particularly in the areas of reuse, repurposing, and recycling. These insights underpin the report's key recommendations.

Regulatory Considerations

Regulations

Regulation in the secondary battery reuse, repurpose, and recycle sector is complex and varies across Australian jurisdictions, often leading to inconsistencies that complicate industry operations. The absence of standards, particularly in the reuse and repurpose sectors, creates challenges for regulatory harmonisation. This contrasts with the more regulated recycling sector, which is guided by environmental and planning regulations. Efforts are underway, led by the Queensland, NSW, and Victorian state governments, to address the urgent issue of used battery fires and develop harmonised policies. However, the lack of a cohesive regulatory framework, like the EU Battery Directives, hinders Australia's ability to ensure safety and streamline imports and exports. To mitigate risks and promote industry growth, there is a pressing need for consistent national standards and regulations across the entire supply chain, ensuring minimum safety standards are met and facilitating better management of used batteries.

The Dangerous Goods Acts from each state and territory, could be updated to more accurately designate used batteries by refining their classification within Class 9 (Miscellaneous Dangerous Goods). Currently, lithium-ion batteries are grouped broadly under this category, which does not fully account for the specific risks they pose, such as thermal runaway, fire, and potential environmental hazards. An update could involve creating a distinct subclass within Class 9 specifically for used batteries, with tailored requirements for their handling, storage, and transportation. This change could then be incorporated as an update to AS 4681:2000, *The Storage and Handling of Class 9 (Miscellaneous) Dangerous Goods and Articles,* to more effectively address the specific requirements for battery storage and handling.

Consumer & Industry Education

Education and awareness are critical components for both consumers and industry in the context of secondary batteries. For consumers, it's essential to provide clear guidance on the proper disposal and recycling of batteries, especially given the varied chemistries that require specific handling. Onsite retail collection bins are one avenue for collection, but they need to be accompanied by education that clarifies which batteries can be mixed and how they should be deposited. Moreover, there's a need to raise awareness about available collection points for batteries and e-waste generally to ensure these are properly recycled.

From an industry perspective, there is a growing need for education around the certification and recertification of reused batteries. In addition, repurposed batteries should meet strict safety standards to prevent hazards such as fires or leaks, and consumer protection must be upheld by ensuring that repurposed products are reliable, durable, and supported by warranties or guarantees. Transparent information disclosure is critical, allowing consumers to understand the battery's history, performance limitations, and proper handling. Finally, through safety standards, insurance coverage should be considered to manage any potential risks associated with repurposed battery failures, providing a safeguard for both consumers and businesses.

As global markets increasingly prioritise the ethical and environmental implications of products, industry stakeholders must be educated on Environmental, Social, and Governance standards, particularly in the battery sector. This includes educating accreditors on the importance of these certifications for reused or repurposed batteries.

Governments also play a key role in this educational landscape. The Australian Government has recognised the importance of education and industry development in the battery sector, allocating $10 million to enhance battery industry skills and training. There is also an ongoing need for government awareness regarding the lack of recycling facilities particularly those capable of processing black mass from batteries, which underscores the necessity for further investment and infrastructure development. More can be done to ensure that such initiatives are effectively communicated and implemented across both consumer and industry segments.

Safety Impacts

Safety in the reuse, repurpose, and recycling of secondary batteries is a growing concern as the industry grapples with the inherent fire risks associated with lithium batteries. The increasing prevalence of lithium-ion batteries, particularly in e-mobility devices such as e-scooters and e-bikes, has led to a rise in fire incidents, especially in residential areas. These fires are not only dangerous but also pose significant challenges to waste management systems, where the improper disposal and collection of batteries can result in fires within waste streams, collection vehicles, and storage facilities. The current lack of clear and consistent storage standards across various fire agencies has further exacerbated these risks, underscoring the urgent need for comprehensive safety guidelines.

Mitigating the fire hazards associated with secondary batteries requires a multi-faceted approach that addresses the unique challenges posed by different battery chemistries and sizes. For instance, small lower quality batteries, which are often more prone to thermal runaway, should be stored in containers filled with vermiculite to reduce the risk of fire. Large batteries, such as those used in energy storage systems and electric vehicles (EVs), need to be carefully segregated by chemistry and stored on pallets that are separated by firewalls to prevent the spread of fire. Additionally, specific storage protocols must be developed to cater to the varying fire risks associated with different battery types. For example, while lithium-ion batteries require stringent measures to mitigate fire risks, lead-acid batteries, which are less prone to fire, require more attention to spill prevention.

In addition to safe storage, the handling and transportation of secondary batteries are critical aspects of safety that demand careful consideration. One of the most effective ways to reduce fire risks during transportation and processing is to ensure that batteries are discharged to the lowest possible state of charge before they are moved or recycled. This practice not only makes the batteries safer to transport but also reduces the likelihood of fire during sorting and shredding at recycling facilities. The development of national safety standards for battery storage, handling, and transportation is essential to ensure that all stakeholders, including waste management facilities, recycling centres, and logistics companies, adhere to best practices. These standards should also incorporate guidance on fire risk assessments, storage infrastructure, and emergency response procedures, ensuring that facilities are adequately prepared to manage battery-related fire incidents.

Furthermore, collaboration between the battery industry, fire agencies, and regulatory bodies is crucial to establishing a robust safety framework. This includes developing guidelines for the safe handling and storage of batteries at various stages of their lifecycle, from new batteries to end-of-life processing. It also involves engaging with original equipment manufacturers to obtain critical safety information that can help recycling operators manage the risks associated with battery storage and handling. The need for national standards is particularly pressing as the industry continues to evolve, with increasing volumes of batteries entering the reuse, repurpose, and recycling streams. By implementing comprehensive safety measures and fostering collaboration across the industry, it is possible to mitigate the risks associated with secondary batteries, thereby supporting a safer and more sustainable circular economy.

Identification and Traceability in the Battery Lifecycle

The development of comprehensive battery labelling standards is a critical challenge for Australia, especially considering advancements in regions like Japan and the European Union (EU). While Japan has established strong labelling practices, Australia currently lacks a robust framework for battery registration and labelling, which is essential for maintaining battery information and traceability. This gap is particularly evident when comparing the existing lead-acid battery labelling standards with the inconsistent labelling requirements for lithium batteries, which are increasingly important given their environmental impacts.

The introduction of a labelling scheme, like the battery passport being developed in Europe for large format batteries, could significantly improve traceability and inform consumers about important aspects such as the presence of Per- and Polyfluoroalkyl Substances (PFAS) chemicals in products. Such a scheme could also ensure that testing information gathered during the battery's lifecycle, especially during triage for reuse or repurposing, is effectively captured and linked to the battery through its label, potentially using QR codes for easy access to this data.

Australia, as a participant in the global battery recycling economy, has an opportunity to align with the EU's battery passport and traceability requirements. However, the specifics of how these European standards will be adopted in Australia remain unclear. Some organisations are proactively recording comprehensive battery information in anticipation of future regulations, but there is still a need for a clear, standardised approach. By establishing a concrete definition of the metadata to be recorded and implementing consistent labelling practices, Australia could enhance its role in the circular battery economy and ensure that batteries are managed sustainably throughout their lifecycle.

Used Battery Supply Chain Challenges

This section addresses the critical considerations across the used battery supply chain. Effective collection and transportation require stringent safety measures, adaptable standards, and strategic planning to manage the varying requirements of different battery types and chemistries. Additionally, the sorting, testing, and storage of batteries are crucial for determining their suitability for reuse, repurposing, or recycling. However, the lack of standardised testing processes and clear storage guidelines poses significant challenges, underscoring the need for consistent criteria and comprehensive safety protocols.

Furthermore, the reuse and repurpose of batteries offer significant potential to extend their lifecycle, particularly in the growing electric vehicle (EV) sector. Yet, the complexities of battery disassembly, testing, and regulatory challenges hinder these efforts. This report highlights the importance of sustainable disassembly and material recovery practices, advocating for forward-thinking battery design to facilitate recycling and maximise material recovery. Overall, establishing comprehensive standards across all stages of the battery lifecycle is essential to creating a safer, more efficient, and sustainable battery ecosystem.

The used battery supply chain flow chart outlines the two key pathways: recycling and reuse/repurpose (Figure 6). While the chart provides a generalised overview applicable to all battery types and chemistries, it serves as a broad framework. For a more precise representation, specific use-case flow charts would be needed to address specific battery chemistries and applications.

The condition of used batteries generally falls into four categories:

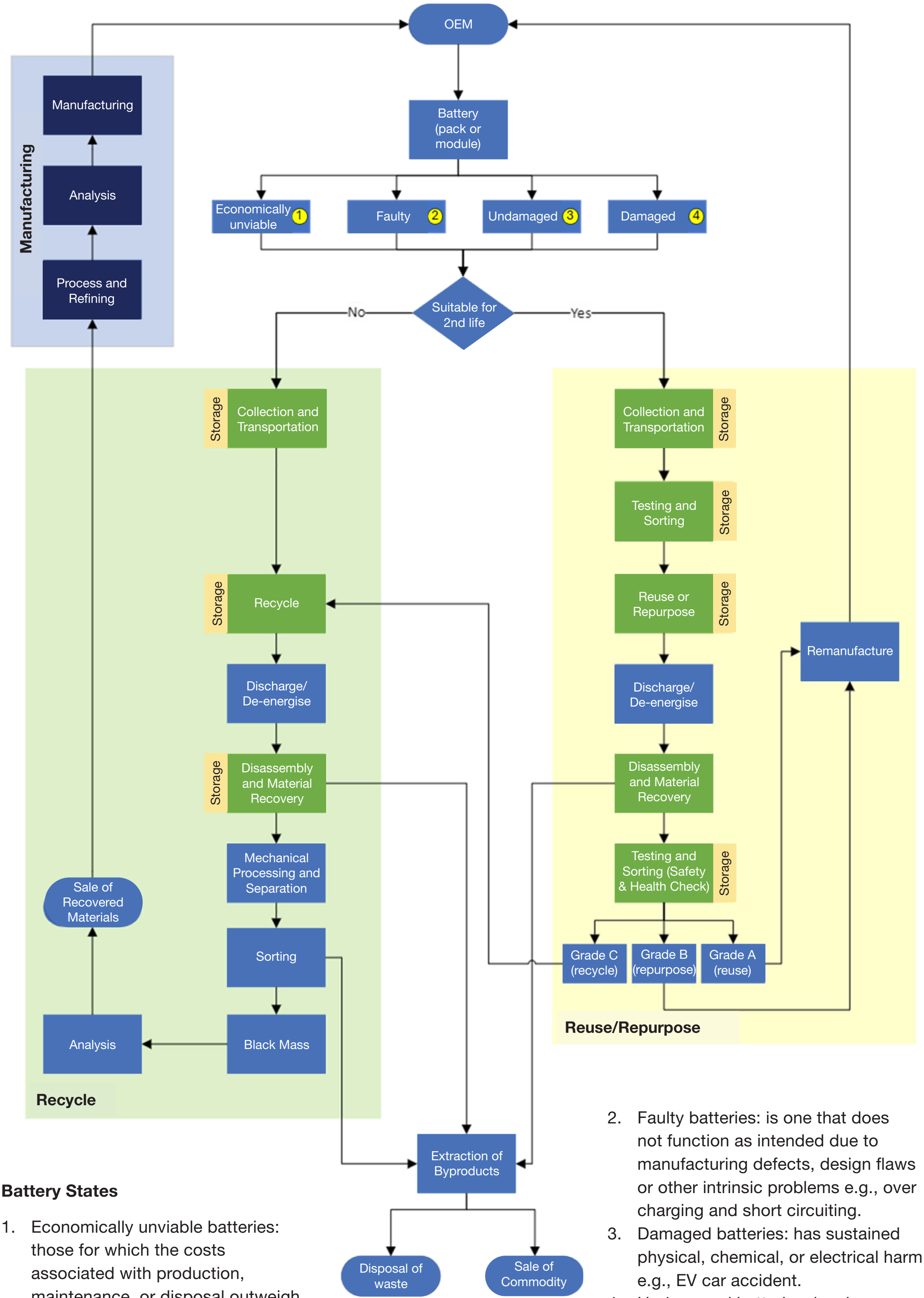
- **Damaged batteries:** These have sustained physical, chemical, or electrical harm, such as those from an EV car accident.
- **Undamaged batteries:** Although associated with an incident, these batteries remain intact and unharmed, for example, a battery from a totalled EV car that suffered no damage.
- **Faulty batteries:** These do not function as intended due to manufacturing defects, design flaws, or intrinsic issues, such as overcharging or short-circuiting.

- **Economically unviable batteries:** These batteries are no longer cost-effective due to high production, maintenance, or disposal costs that outweigh their financial benefits, for instance, batteries that experience faster capacity loss from deep and frequent cycling.

Key areas where standards play a crucial role include:

- **Collection & Transportation:** This involves gathering and transporting discarded rechargeable batteries to designated facilities for further processing, ensuring safe handling and compliance with regulatory standards.
- **Sorting & Testing:** Batteries are sorted by chemistry and assessed for their suitability for second-life applications or material recycling. Testing during this stage ensures accurate sorting and maximises the value of each battery.
- **Reuse & Repurpose:** This stream focuses on extending the life of batteries beyond their original use. Batteries may be rebuilt from functional modules or cells for new applications, such as stationary energy storage systems.
- **Disassembly & Material Recovery:** Disassembly is vital for recycling, as it allows for the early separation of components made from various materials. Valuable materials are recovered and refined to high purity levels, ready to be sold as commodities.
- **Recycling:** Involves mechanical crushing and chemical processing of used batteries, yielding metals or alloys with varying levels of purity for further use in manufacturing.

Generalised Used Battery Supply Chain



Battery States

1. Economically unviable batteries: those for which the costs associated with production, maintenance, or disposal outweigh the financial benefits of their use e.g., batteries that cycle deeper and more frequently can lead tofaster capacity loss
2. Faulty batteries: is one that does not function as intended due to manufacturing defects, design flaws or other intrinsic problems e.g., over charging and short circuiting.
3. Damaged batteries: has sustained physical, chemical, or electrical harm e.g., EV car accident.
4. Undamaged batteries: has been associated with an incident but remains undamaged e.g., EV car accident right-off but no damage to battery.

Figure 6: Generalised Reuse Repurpose Recycle Supply Chain.

Collection & Transportation

Effective collection and transportation of secondary batteries rely on stringent safety measures, consistent standards, and strategic planning. Given the varying requirements of different battery types and chemistries, it is essential to establish comprehensive and adaptable standards. This approach will streamline operations, reduce risks, and ensure compliance with regulations, ultimately fostering a safer and more efficient battery recycling ecosystem.

<u>Collection and Storage Locations</u>

Each battery collection location must adhere to regulations set by Building Codes Australia (BCA), fire safety standards, and EPA guidelines. Different retail collection points and collection methods (e.g., automotive service shops, energy storage installers, small battery collections) require tailored approaches due to varying battery types and volumes. In practice, collection points have little control over the types of batteries deposited.

For larger batteries, lithium batteries are reported to being mixed with lead-acid batteries due to their similar appearance. Additionally, the higher cost of proper disposal often deters people from separating them. Recyclers then bear the burden of sorting and separating these batteries. Increasing public awareness about battery collection points can improve the effectiveness of these systems.

Battery collection and storage facilities should be located at a safe distance from populated areas and property to minimise risks from potential fires, explosions, or hazardous material leaks. Sites should be carefully selected to avoid ecologically sensitive areas, such as water bodies, wetlands, or regions prone to flooding, ensuring minimal environmental impact from potential contamination. One potential solution is to use storage with integrated sensors to monitor conditions, which can reduce costs and manage hazards associated with different battery types. The complexity of managing fire risks during collection and transportation necessitates stringent safety measures and consistent standards.

A comprehensive accreditation document could serve as the basis for these standards, provided it aligns with existing waste regulations. Different battery types and chemistries require specific collection requirements, making standardised solutions challenging. Strategically selecting storage locations can significantly reduce transportation needs. Throughout the supply chain, the processes of collection, transportation, sorting, and testing vary based on battery chemistries and their uses, highlighting the need for adaptable and comprehensive standards.

<u>Collection Containers</u>

There are diverse container protocols at drop-off locations, each with limited labelling to simplify the process and encourage use. To enhance onsite safety, these locations must demonstrate their ability to manage fire risks and use heat detection sensors to alert emergency services. Collection bins face challenges in managing different battery chemistries, often resulting in mixed batteries that require EPA notification for transportation.

<u>Transportation</u>

A uniform set of standards or best practice guidance adopted by all states and territories could streamline cross-border battery transportation, reducing costs and logistical challenges. For instance, transporting a battery within an EV is straightforward, but special permits are needed once the battery is removed from the vehicle. The UN 38.3 standard, primarily for new lithium battery transportation, does not fully address the complexities of used batteries. Some recyclers have developed their own packing standards, with tested cartons supplied to customers for safe transportation to their facility.

Transporting batteries safely involves testing them to ensure they are below 30% state of health, marking the end-of-life pathway and making them safer for transportation. The total volume of batteries is a key factor in storage and transportation logistics.

Sorting & Testing

The process of sorting and testing large format secondary batteries is critical for determining their suitability for reuse, repurposing, or recycling. The initial stage, often referred to as triaging, involves testing to assess the condition of the battery and its potential for a second life. However, this process is not universally applied across all battery types and chemistries, as the requirements and methods for testing can vary significantly depending on the specific characteristics of the battery.

Testing is a crucial decision point in the battery lifecycle, especially for identifying whether a battery has sufficient capacity and structural integrity to be repurposed or if it should be recycled. Unfortunately, testing at the recycling stage is almost non-existent due to the lack of accessible information, such as usage hours, which could aid in the sorting process. As a result, most batteries reaching recyclers are treated as end-of-life products, with no consideration for potential reuse or repurposing.

The absence of standardised testing processes across the industry has been a significant barrier to supporting the growth of the battery reuse sector. While many IEC standards exist for testing the quality of new batteries, there are few standards related specifically to lifecycle testing, making it challenging to establish consistent criteria for evaluating batteries at the end of their initial use. The testing that is conducted, particularly at the reuse and repurpose levels, is not equivalent to the rigorous testing required for new batteries. Instead, it is often reverse engineered based on criteria set by the original equipment manufacturers, leading to a wide variance in testing practices.

Moreover, testing should ideally be conducted not just at the battery pack level but also down to the module level, depending on the battery architecture. However, the diversity in battery designs and the lack of clear guidelines make it difficult to standardise testing processes. In some cases, the risk involved in manually disassembling and testing batteries is too great, leading to a preference for recycling over reuse.

For large format batteries that have been damaged or exposed to harsh conditions, the testing and handling protocols differ significantly from those applied to healthy batteries. Despite these challenges, testing remains a vital component of ensuring that batteries meet functional and safety requirements before being repurposed. This involves not only performance tests, such as leak and pressure tests, but also software diagnostics for components like battery management systems (BMS).

Discussions with original equipment manufacturers are ongoing to better understand and align testing regimes with industry standards. The development of a consistent, standardised testing framework is essential, including the preservation and recording of testing data. However, there is currently no concrete definition on how to manage this data, particularly within the emerging battery passport programs. The global harmonisation efforts, such as those by the UN on chemical labelling and the issuance of new UN numbers for batteries, underscore the importance of creating clear and comprehensive testing standards to support the safe and effective reuse and recycling of secondary batteries.

Storage

The storage of secondary batteries is a critical concern across various industries, yet there is a notable lack of clarity and standards, particularly in collaboration with fire agencies and waste management facilities. The safe handling and storage of used batteries, especially lithium-ion batteries, present significant risks due to their classification as Class 9 miscellaneous dangerous goods. Despite this classification, the current storage guidelines are inadequate and are often improperly applied, as they were originally intended for chemical substances rather than batteries.

Different battery chemistries and formats require distinct storage protocols, making the development of standardised guidelines even more challenging. The risks associated with improper storage are particularly high, given the increased energy capacity of modern batteries, which can lead to fire hazards. These risks are further compounded during the various storage phases that batteries may undergo, from initial collection to larger consolidations at recycling facilities.

To mitigate these risks, best practices for storage must be urgently developed, tailored to the needs of different sectors, including recycling, reuse, and repurposing industries. The establishment of comprehensive storage standards would not only enhance safety but also support the circular economy by ensuring batteries are stored appropriately until they are either reused, repurposed, or recycled.

There is a pressing need for a best practice guide that could eventually evolve into a formal standard, providing clear and actionable guidance for all stakeholders, including ports, warehouses, and solar installation companies. This guide should address specific storage requirements for different battery types, formats, and conditions, including considerations for mechanical deformation and the state of charge.

Moreover, while some work has been done at the state level, such as in New South Wales, to develop safe storage standards, a more consolidated and comprehensive approach is needed at the national level. This approach should include input from original equipment manufacturers to ensure that storage practices are aligned with the unique characteristics of each battery type.

Ultimately, the development of clear and robust storage guidelines is of immediate importance. It represents an opportunity to address current gaps in safety protocols, reduce fire risks, and support the sustainable management of secondary batteries across their entire lifecycle.

Reuse & Repurpose

The reuse and repurpose of secondary batteries is an emerging area with significant potential, but also considerable challenges. Reuse refers to utilising a battery for its original intended purpose, often in the same application such as returning a battery to an electric vehicle (EV). Repurposing, on the other hand, involves using a battery for a different, often less demanding, application when its performance no longer meets the requirements for its original use.

The process of determining whether a battery is suitable for reuse, repurpose, or recycling typically begins with a triage system, where batteries undergo testing to assess their state of health and potential future applications. This process is crucial because it allows batteries that are still functional but no longer optimal for their original use to be diverted to other applications, extending their lifecycle and contributing to a more sustainable battery ecosystem.

However, the current lack of standardised guidelines and technologies for disassembly and testing makes it difficult to efficiently reuse or repurpose batteries. Each battery pack is different, often incorporating proprietary technologies, which complicates the process. Additionally, the absence of a clear definition of what constitutes reuse or repurpose can create regulatory challenges, particularly in relation to waste management and export permits.

The reuse and repurposing of EV batteries represent the most significant opportunities due to the way these batteries are designed and their typical duty cycles. As the EV market grows, the volume of batteries available for reuse or repurpose is expected to increase. However, for large-scale battery systems, reuse may be less feasible due to their size and the complexity of accessing and testing individual batteries.

Insurance practices also pose a challenge, as EV batteries are often written off after any damage, regardless of their actual condition, pushing them prematurely into the recycling stream.

Functional and safety requirements for reused batteries must be met in consultation with original equipment manufacturers. There is also a need to educate consumers and industry stakeholders about the potential for multiple owners of a reused battery, which requires a shift in thinking and approach.

Overall, while the potential for reuse and repurposing secondary batteries is significant, realising this potential will require overcoming regulatory, technological, and market challenges.

Disassembly & Material Recovery

The sustainable design and disassembly of secondary batteries are critical components of the circular economy, with a strong emphasis on design for disassembly to facilitate material recovery. However, the diverse construction of battery packs, each with unique proprietary technologies, presents significant challenges for disassembly, particularly when batteries are embedded with various materials that are difficult to separate. This complexity is exacerbated by safety concerns, as manual disassembly requires skilled labour, and the current technology makes automated or robotic disassembly challenging due to the tightly packed and sealed nature of many battery packs.

The disassembly process varies depending on the end-of-life pathway. For reuse, a battery pack may be disassembled to replace an underperforming module, allowing the rest of the pack to be repurposed. However, the risk and complexity of manual disassembly often leads to the entire battery being written off and sent directly to recycling, where it is crushed, and valuable materials are extracted. This approach highlights the need for forward thinking in battery design, particularly for applications like static storage, where automated disassembly could be more feasible if batteries were designed with this in mind.

Australia has the potential to develop a robust domestic recycling industry, with estimates suggesting that the country could generate 137 tonnes of lithium from battery waste annually, representing a market value of up to $600 million per year or $3 billion over the next decade. To maximise this potential, it is crucial to follow environmental standards for safely handling hazardous waste and recovering valuable materials. Recovered materials, such as metals and plastics, can be sold as commodities, while the black mass, a byproduct of recycling, is currently shipped overseas. Ideally, Australia should invest in refining black mass into high-purity chemical feedstocks domestically, adding significant value to the recycling process.

However, for Australia to capitalise fully on this opportunity, there is a need for increased volumes to justify the investment in automated disassembly and refining processes. Additionally, the regulatory framework would need to be carefully examined to accommodate the deep dive into material recovery and the potential environmental impacts of refining high-purity chemicals from battery waste. By addressing these challenges, Australia could not only enhance its recycling capabilities but also position itself as a leader in sustainable battery material recovery.

Recommendations

Recommendation 1: Update AS 4681:2000, *The Storage and Handling of Class 9 (Miscellaneous) Dangerous Goods and Articles,* to better address battery storage and handling

Recommendation: Standards Australia and industry stakeholders should collaborate to propose a revision of AS 4681:2000, *The Storage and Handling of Class 9 (Miscellaneous) Dangerous Goods and Articles,* to more effectively address the unique storage and handling requirements of batteries. However, this update is contingent upon the Australian government's first modifying the relevant Dangerous Goods Acts to reclassify batteries, reflecting their specific risks more accurately. Alternatively, a new, dedicated standard or best practice guide could be developed specifically for battery storage and handling, distinct from other miscellaneous dangerous goods.

Rationale: The current classification of batteries under AS 4681:2000, *The Storage and Handling of Class 9 (Miscellaneous) Dangerous Goods and Articles,* does not adequately address the specific risks associated with battery storage and handling. Batteries, particularly those containing lithium, pose unique safety concerns, such as thermal runaway, chemical leakage, and fire hazards, which are not fully covered by the general provisions of this standard. Updating the standard or creating a new one specifically for batteries would offer clearer guidance and ensure best practices are followed in their storage and handling.

Expected Benefits:

- **Enhanced Safety**: A dedicated standard or updated guidelines would directly address the unique hazards associated with batteries, reducing the risk of incidents such as fires, chemical spills, or explosions during storage and handling.
- **Clarity for Industry**: By distinguishing batteries from other Class 9 goods, industries handling large volumes of batteries will have clear, specific guidelines to follow, reducing confusion and ensuring compliance with the most appropriate safety measures.
- **Environmental Protection**: Proper storage and handling reduce the likelihood of environmental contamination from battery leaks or improper disposal, contributing to better environmental stewardship.
- **Facilitation of Recycling:** Clear guidelines on storage and handling can improve the condition of batteries when they enter the recycling stream, enhancing the efficiency and effectiveness of recycling processes.

Recommendation 2: Develop a standard to test suitability of used batteries for reuse, repurpose and recycling

Recommendation: Standards Australia and industry stakeholders should collaborate to propose to develop a new standard specifically focused on testing protocols for determining the suitability of used batteries for reuse, repurposing, or recycling. This standard should define clear testing methodologies and criteria for assessing the remaining capacity, safety, and performance of used batteries, establishing limits that will guide their optimal end-of-life pathways.

Rationale: As the use of battery-powered technologies expands, effective management of used batteries will be increasingly important. Currently, the lack of specific international standard testing procedures for determining whether a used battery should be reused, repurposed, or recycled poses risks of unsafe reuse, suboptimal repurposing, and inefficient recycling. Establishing a dedicated standard would address these issues by providing a consistent framework for assessing used batteries, promoting safe and sustainable practices. This standard would also require original equipment manufacturers to share crucial battery information, facilitating more informed and secure management of batteries throughout their lifecycle.

Adopting such a standard would position Australia as a leader in battery testing and lifecycle management.

Expected Benefits:

- **Enhanced Safety**: Rigorous testing protocols will ensure that only batteries meeting safety thresholds are reused or repurposed, reducing the risk of accidents.
- **Optimised Resource Utilisation:** Standardised testing will help identify the best end-of-life option for batteries, maximising value from repurposing or recycling based on remaining capacity.
- **Increased Market Confidence:** A formal standard will assure businesses and consumers of the safety and reliability of reused batteries, boosting confidence in the secondary battery market.

Recommendation 3: Adopt UL 1974, *Evaluation for Repurposing or Remanufacturing Batteries*

Recommendation: Standards Australia and industry stakeholders should collaborate to propose to adopt UL 1974, *Evaluation for Repurposing or Remanufacturing Batteries,* as a key standard for assessing the viability of repurposing or remanufacturing used batteries. This standard provides a comprehensive framework for evaluating the safety, performance, and reliability of secondary batteries when they are repurposed or remanufactured for new applications.

Rationale: As sustainability and the circular economy gain importance, repurposing and remanufacturing used batteries have become crucial. UL 1974*, Evaluation for Repurposing or Remanufacturing Batteries*, provides a structured approach to ensure these processes are conducted safely and effectively. Adopting this standard in Australia would promote best practices in battery reuse and repurposing, ensuring thorough evaluation of used batteries before they are introduced into new applications.

Expected Benefits:

- **Enhanced Safety:** UL 1974, *Evaluation for Repurposing or Remanufacturing Batteries* provides rigorous criteria for assessing the safety of repurposed or remanufactured batteries. Adoption of this standard will help mitigate risks associated with the use of used batteries, including potential safety hazards related to performance and reliability.
- **Improved Performance and Reliability:** The standard's evaluation processes ensure that repurposed or remanufactured batteries meet specific performance benchmarks. This helps maintain high standards of reliability and effectiveness in their new applications.
- **Support for the Circular Economy**: Adopting UL 1974, *Evaluation for Repurposing or Remanufacturing Batteries,* aligns with the principles of the circular economy by promoting the reuse and remanufacturing of batteries. This supports Australia's sustainability goals by extending the lifecycle of battery materials and reducing waste.
- **Consistency and Standardisation:** Implementing UL 1974, *Evaluation for Repurposing or Remanufacturing Batteries,* provides a standardised framework for battery evaluation, ensuring consistency across the industry. This facilitates clearer guidelines for manufacturers and recyclers and helps harmonise practices within the sector.
- **Consistency with International Standards:** UL 1974 Evaluation for Repurposing or Remanufacturing Batteries is widely recognised internationally, and adopting it aligns Australia with global best practices, enhancing compatibility and standardisation in battery management.

Recommendation 4: Adopt J17152, *Battery Terminology*

Recommendation: Standards Australia and industry stakeholders should collaborate to propose to adopt J17152, *Battery Terminology,* provided that its definitions are aligned with existing waste management terminology. This standard provides comprehensive terminology for various types of batteries and their related concepts, which can enhance clarity and consistency across the battery industry.

Rationale: Clear and consistent terminology is key to effective communication and regulatory compliance in the battery industry. Adopting J17152 Battery Terminology will standardise language in battery management, ensuring alignment with waste management terminology. This will enhance coherence and integration between battery management and waste management practices.

Expected Benefits:

- **Enhanced Clarity and Consistency:** Adopting J17152, *Battery Terminology*, will standardise language, reducing confusion and ensuring consistent communication across the industry and regulatory bodies.
- **Improved Regulatory Compliance:** Standardised terminology will simplify adherence to both battery management and waste management regulations, easing compliance for companies.
- **Facilitation of Data Management and Collaboration:** Consistent terminology will improve data accuracy and foster better collaboration among stakeholders, supporting effective battery lifecycle management and decision-making.

Recommendation 5: Develop a safety standard on discharging batteries prior to storage and disposal

Recommendation: Standards Australia and industry stakeholders should collaborate to develop a comprehensive safety standard or best practice guide that provides guidance for the discharge of batteries prior to their storage and disposal. This standard should outline procedures and safety measures for effectively discharging various types of batteries, including lithium-ion, lead-acid, and other chemistries, to ensure safe handling and minimise risks.

Rationale: Discharging batteries before storage and disposal is essential for minimising the risks of fires, chemical leaks, and other hazards, especially with lithium-ion batteries, which are particularly hazardous if not managed properly. Implementing a standard or best practice guide for battery discharge would establish clear protocols to mitigate these risks, enhance safety, and ensure regulatory compliance. This standard would also mandate that original equipment manufacturers provide relevant battery information, supporting informed and safe practices in the reuse, repurposing, and recycling of batteries.

Expected Benefits:

- **Enhanced Safety**: Standardising battery discharge procedures will reduce risks of fires, explosions, and chemical leaks, improving safety during storage and disposal.
- **Improved Handling Procedures and Industry Standards:** Clear guidelines will standardise handling practices, reduce accidents, and elevate overall battery management standards.
- **Compliance with Best Practices and Regulations:** Establishing a discharge standard will ensure alignment with industry best practices and regulatory requirements, supporting safer operations and future regulatory compliance.

Recommendation 6: Adopt international standards for safe handling of batteries

Recommendation: Standards Australia and industry stakeholders should collaborate to propose to adopt international standard J2950_202006, *Recommended Practices for Shipping, Transport, and Handling of Automotive-Type Battery Systems - Lithium Ion,* to enhance the safety and management of battery handling in Australia. This standard should be tailored to local conditions and regulatory requirements to ensure comprehensive safety practices are applied across various battery types and applications.

Rationale: The international standard J2950_202006, *Recommended Practices for Shipping, Transport, and Handling of Automotive-Type Battery Systems - Lithium Ion,* establishes guidelines for the safe handling, transport, and storage of lithium-ion batteries. Adopting and adapting these standards in Australia will enhance safety, efficiency, and alignment with global best practices in battery management.

Expected Benefits:

- **Enhanced Safety and Regulatory Compliance:** Adopting international standards will provide robust safety guidelines and ensure compliance with both local and global regulations, reducing risks and facilitating smoother operations.
- **Consistency with Global Best Practices:** Aligning with established international standards will enhance operational efficiency and safety, aligning Australian practices with global best practices.
- **Increased Market Confidence and Support for Innovation**: Adherence to recognised standards will boost confidence among stakeholders and support innovation in battery technology and management.

Recommendation 7: Monitor standards under development for consideration of adoption

Recommendation: Standards Australia should implement a systematic approach to monitor and evaluate the standards currently under development, including IEC 62635 ED1, *Guidelines for end-of-life information provided by manufacturers and recyclers and for recyclability rate calculation of electrical and electronic equipment,* IEC 63338 ED1, *General guidance on reuse and repurposing of secondary cells and batteries,* and IEC 63330-1 ED1, *Repurposing of secondary batteries - Part 1: General requirements*, to assess their relevance and potential for adoption within Australia. Proactive monitoring should include regular reviews of draft documents, participation in relevant working groups, and engagement with international standardisation bodies to ensure timely and informed decisions regarding the adoption of these standards.

Rationale: The three identified IEC standards are key to managing battery systems, covering end-of-life, reuse, and repurposing. By monitoring these standards, Australia can align with international advancements and ensure its frameworks reflect the latest best practices in battery technology.

Expected Benefits:

- **Alignment with International Standards**: Monitoring and adopting these standards will ensure that Australia's practices are consistent with global best practices, promoting international compatibility and enhancing the credibility of Australian standards.
- **Enhanced Regulatory Framework:** Adoption of these standards will help strengthen Australia's regulatory framework for battery management, ensuring comprehensive coverage of critical aspects such as end-of-life management, safety, and reuse.
- **Informed Stakeholder Engagement**: Keeping stakeholders informed about the latest developments in standards will facilitate better planning and preparation, ensuring a smoother transition when new standards are adopted.

Recommendation 8: Develop standard on easy-to-recycle battery designs

Recommendation: Standards Australia and industry stakeholders should collaborate to develop and implement a standard, or guideline that provides guidance for easy-to-recycle battery designs. This standard or guideline should detail requirements for original equipment manufacturers to register and comply with labelling and design standards that facilitate efficient recycling processes. The standard should include specific criteria for design practices, labelling, and registration to ensure batteries are designed with end-of-life management in mind.

Rationale: The growing volume of used batteries challenges recycling and environmental management. Mandating easy-to-recycle designs will streamline recycling, reduce contamination, and boost material recovery. Requiring manufacturers to follow these guidelines will enhance battery sustainability and support a circular economy.

Expected Benefits:

- **Enhanced Recycling Efficiency and Reduced Environmental Impact:** Designing batteries with recycling in mind will improve material recovery, reduce waste, and minimise environmental footprint through better disposal practices.
- **Standardisation and Increased Consumer Awareness:** A clear design and labelling framework will standardise industry practices, ensure compliance, and help consumers dispose of batteries properly, boosting recycling rates.
- **Encouragement of Sustainable Practices and Cost Savings:** Mandating easy recycling designs will drive innovation in sustainable practices, reduce recycling costs, and enhance market access and regulatory compliance.

Recommendation 9: Australia to participate in key IEC battery working groups

Recommendation: Standards Australia should become either a participant or observer in IEC SC 21A's working groups PT 63330 and PT 63338. This involvement would enable Australia to actively contribute to the development of key standards—IEC 63330, *Repurposing of Secondary Batteries – Part 1: General Requirements and IEC 63338 General Guidance for Reuse of Secondary Cells and Batteries.* Such participation will ensure that Australia's interests are represented in these critical areas, supporting the safe, efficient, and sustainable management of secondary batteries.

Rationale: The global battery industry is rapidly evolving, focusing on repurposing and reusing secondary batteries for sustainability. IEC 63330 and IEC 63338 are key standards in development that will guide these practices. By participating in these working groups, Australia can shape these standards to address both international and local needs, ensuring effective adoption and maintaining a leadership role in global best practices.

Expected Benefits:

- **Influence on International Standards and Support for National Energy Goals:** Australia's participation in PT 63330 and PT 63338 will shape standards to align with local needs and support national energy, sustainability, and circular economy goals.
- **Enhanced Industry Competitiveness and Improved Safety:** Early involvement will give Australian companies a competitive edge, ensure alignment with up-to-date safety standards, and reduce risks in battery repurposing and reuse.
- **Capacity Building and International Recognition**: Engagement will build national expertise, enhance Australia's reputation in sustainable battery management, and attract global investment and collaboration opportunities.

Recommendation 10: Australia to participate in key IEC battery technical committee

Recommendation: Standards Australia should become either a participant or observer in IEC Technical Committee 35 (TC 35) on Primary Cells and Batteries and actively engage in Working Group JMT 18, which focuses on the safety of primary and secondary lithium batteries during transport. This involvement will allow Australia to contribute to and influence the development of international standards governing the safe transport of lithium batteries.

Rationale: Transporting lithium batteries poses safety risks, including overheating, fires, and explosions. As their use expands, robust safety standards are essential. By joining Working Group JMT 18, Australia can ensure its regulatory and safety needs are met, resulting in practical and effective standards for its context.

Expected Benefits:

- **Enhanced Safety Standards and Industry Confidence:** Involvement in JMT 18 will help Australia influence comprehensive safety standards for lithium batteries, addressing safety concerns and boosting industry confidence.
- **Alignment with International Best Practices and Support for National Frameworks:** Participation will ensure Australia's regulations align with global standards, simplifying compliance and facilitating safer global trade.
- **Improved Market Competitiveness and Reduced Compliance Costs**: Engaging in standard development will help Australian businesses anticipate changes, reduce compliance costs, and maintain a competitive edge in the global market.

Recommendation 11: Circularise relevant battery standards to promote sustainability

Recommendation: Standards Australia should work to amend and circularise all relevant battery standards across industries to embed principles of the circular economy, thereby ensuring that sustainability is a core consideration in the design, production, use, and end-of-life management of products and materials.

Rationale: Traditional "take, make, dispose" models are unsustainable due to finite resources and environmental concerns. Adopting circular economy standards for batteries promotes resource efficiency, waste reduction, and continuous material use. Integrating these principles into existing standards will ensure sustainability is considered throughout a product's entire lifecycle.

Expected Benefits:

- **Resource Efficiency and Waste Reduction:** Circularised standards will enhance resource use, reduce raw material demand, and support recycling and reuse, creating closed-loop systems and minimising environmental impact.
- **Innovation and Economic Growth:** Embedding circular economy principles will drive innovation in product design and materials, fostering new business models and economic opportunities focused on sustainability.
- **Enhanced Competitiveness and Global Alignment:** Adopting circular practices will improve market competitiveness, align with global sustainability goals, and support long-term environmental and economic benefits.

Recommendation 12: Uniform guidance on battery disposal pathways across all sectors

Recommendation: Industry stakeholders should collaborate to establish comprehensive and uniform guidance on battery disposal pathways for all sectors of society, including household consumers, electric vehicle (EV) original equipment manufacturers, and reuse, repurpose, and remanufacture entities. This guidance should outline standardised procedures for the disposal, recycling, and management of batteries across various types and applications.

Rationale: The current fragmented battery disposal landscape, with varying practices and regulations, leads to inefficiencies, environmental harm, and stakeholder confusion. Providing clear, consistent guidance will ensure environmentally responsible management, reduce waste, and improve recovery efforts.

Expected Benefits:

- **Increased Recycling Rates and Environmental Protection**: Uniform disposal practices will simplify collection, improve recycling rates, and reduce environmental contamination.
- **Improved Consumer Awareness and Participation:** Consistent guidance will make it easier for consumers to understand and engage in proper disposal practices.
- **Streamlined Operations and Safety:** Standardised procedures will enhance business operations, reduce costs, and improve safety in battery handling and disposal.

Standards Pathway

Standards Adoption

Designation	Recommendation	Title	Rationale	Proponent
UL 1974	3	Evaluation for Repurposing or Remanufacturing Batteries	UL 1974 provides a structured approach to ensure processes are conducted safely and effectively. Adopting this standard in Australia would promote best practices in battery reuse and repurposing, ensuring thorough evaluation of used batteries before they are introduced into new applications.	Australian Government
J17152	4	Battery Terminology	Clear and consistent terminology is key to effective communication and regulatory compliance in the battery industry. Adopting J17152 will standardise language in battery management, ensuring alignment with waste management terminology.	Australian Government
J2950_202006	6	Safe handling of batteries	J2950_202006 establishes guidelines for the safe handling, transport, and storage of lithium-ion batteries. Adopting and adapting these standards in Australia will enhance safety, efficiency, and alignment with global best practices in battery management.	Australian Government

Standards Revision

Designation	Recommendation	Title	Rationale	Proponent
AS 4681:2000	1	The Storage and Handling of Class 9 (Miscellaneous) Dangerous Goods and Articles,	The current classification of batteries under AS 4681:2000 does not adequately address the specific risks associated with battery storage and handling. Batteries, particularly those containing lithium, pose unique safety concerns, such as thermal runaway, chemical leakage, and fire hazards, which are not fully covered by the general provisions of this standard.	Australian Government

Standards Development

Designation	Recommendation	Rationale	Proponent
Testing protocols for determining the suitability of used batteries for reuse, repurposing, or recycling.	2	The lack of specific international standard testing procedures for determining whether a used battery should be reused, repurposed, or recycled poses risks of unsafe reuse, suboptimal repurposing, and inefficient recycling. Establishing a dedicated standard would address these issues by providing a consistent framework for assessing used batteries, promoting safe and sustainable practices. This standard would also require original equipment manufacturers to share crucial battery information, facilitating more informed and secure management of batteries throughout their lifecycle.	Australian Government
Safety standard on discharging batteries prior to storage and disposal	5	Implementing a standard or best practice guide for battery discharge would establish clear protocols to mitigate risks, enhance safety, and ensure regulatory compliance. This standard would also mandate that original equipment manufacturers provide relevant battery information, supporting informed and safe practices in the reuse, repurposing, and recycling of batteries.	Australian Government

Standards Development - continued			
Designation	**Recommendation**	**Rationale**	**Proponent**
Develop standard on easy-to-recycle battery designs	8	The growing volume of used batteries challenges recycling and environmental management. Mandating easy-to-recycle designs will streamline recycling, reduce contamination, and boost material recovery. Requiring manufacturers to follow these guidelines will enhance battery sustainability and support a circular economy.	Australian Government

International Monitoring & Evaluation			
Description	**Recommendation**	**Rationale**	**Proponent**
Monitor standards under development	7	The three identified IEC standards are key to managing battery systems, covering end-of-life, reuse, and repurposing. By monitoring these standards, Australia can align with international advancements and ensure its frameworks reflect the latest best practices in battery technology.	Standards Australia

International Participation			
Description	**Recommendation**	**Rationale**	**Proponent**
Participate in key IEC battery working groups	9	The global battery industry is rapidly evolving, focusing on repurposing and reusing secondary batteries for sustainability. IEC 63330 and IEC 63338 are key standards in development that will guide these practices. By participating in these working groups, Australia can shape these standards to address both international and local needs, ensuring effective adoption and maintaining a leadership role in global best practices.	Standards Australia
Participate in key IEC battery technical committee	10	Transporting lithium batteries poses safety risks, including overheating, fires, and explosions. As their use expands, robust safety standards are essential. By joining Working Group JMT 18, Australia can ensure its regulatory and safety needs are met, resulting in practical and effective standards for its context.	Standards Australia

Circularisation			
Description	**Recommendation**	**Rationale**	**Proponent**
Circularise relevant battery standards to promote sustainability	11	Traditional “take, make, dispose” models are unsustainable due to finite resources and environmental concerns. Adopting circular economy standards for batteries promotes resource efficiency, waste reduction, and continuous material use. Integrating these principles into existing standards will ensure sustainability is considered throughout a product’s entire lifecycle.	Standards Australia

Industry Guidence			
Description	**Recommendation**	**Rationale**	**Proponent**
Uniform guidance on battery disposal pathways across all sectors	12	The current fragmented battery disposal landscape, with varying practices and regulations, leads to inefficiencies, environmental harm, and stakeholder confusion. Providing clear, consistent guidance will ensure environmentally responsible management, reduce waste, and improve recovery efforts.	Industry

Case study – Used Lead Acid Battery Success Story

Used lead-acid batteries (ULAB) are classified as hazardous and controlled waste across all Australian States and Territories, subjecting them to strict transport regulations, often requiring licensed transport companies for their handling. ULAB presents hazards primarily due to potential liquid leakage, unlike the increasingly prevalent lithium-ion batteries, which pose high flammability risks. ULAB handling and storage are regulated under AS 3780:2008 The Storage and Handling of Corrosive Substances which addresses the unique risks associated with lead-acid batteries.

The impressive 99% recycling rate of ULAB can be attributed to several key factors:

High Recyclability:

- ULABs have an exceptionally high recyclability rate, with nearly 100% of their materials being recoverable.
- Key components, including lead, plastics, and the electrolyte (sulfuric acid), can be efficiently recycled.

Well-Established Nationwide Infrastructure:

- Australia has a well-established infrastructure for the collection and recycling of ULABs.
- There are five operational battery recycling facilities across the country: Renewed Metal Technology in Wagga Wagga, NSW; Hydromet in Unanderra, NSW; Hydromet in Laverton, VIC; V Resources in Logan, QLD; and Nexus Recycling in Bibra Lake, WA.

Commercial Value:

- Lead's high value drives a widespread scrap industry, incentivising the collection of batteries from all parts of Australia.
- The recycling process for ULABs is relatively simple and cost-effective, attributing to the straightforward processing technology involved.

Regulations:

- Stringent national and state regulations oversee the recycling process, ensuring minimal environmental impact.
- Key regulations include the Hazardous Waste Storage Regulations, the Australian Code for the Transportation of Dangerous Goods by Road and Rail, Load Restraint Requirements, the Heavy Vehicle National Law (covering General, Fatigue Management, Mass, Dimension & Loading, and Vehicle Standards), the Hazardous Waste Transport Regulations, and the National Environmental Protection (Movement of Controlled Waste Between States and Territories) Measure.
- Duty of Care' and 'Chain of Responsibility' provisions within these regulations place specific obligations on battery users and recyclers. These entities must ensure proper storage, handling, and transportation of batteries by their staff and suppliers. Companies may be held liable for any breaches unless they can demonstrate that they took all reasonable precautions to prevent such occurrences.

Case study – Used Lead Acid Battery Success Story - continue

The Australian Battery Recycling Initiative (ABRI), the peak industry body for battery recycling, has released a series of best practice guides outlining the regulatory requirements and operational recommendations for the storage, handling, and transportation of batteries. These guides cover:

- ABRI Guidelines: Packaging and Safe Transport of ULAB.
- ABRI Consumer Guide to Recycling & Responsible End-of-Life Management of Battery Energy Systems.
- ABRI Battery Recycling Guideline: Storing, Packing & Safe Transport of Mixed Batteries Guidelines for Safe Use and Disposal of Button Batteries.

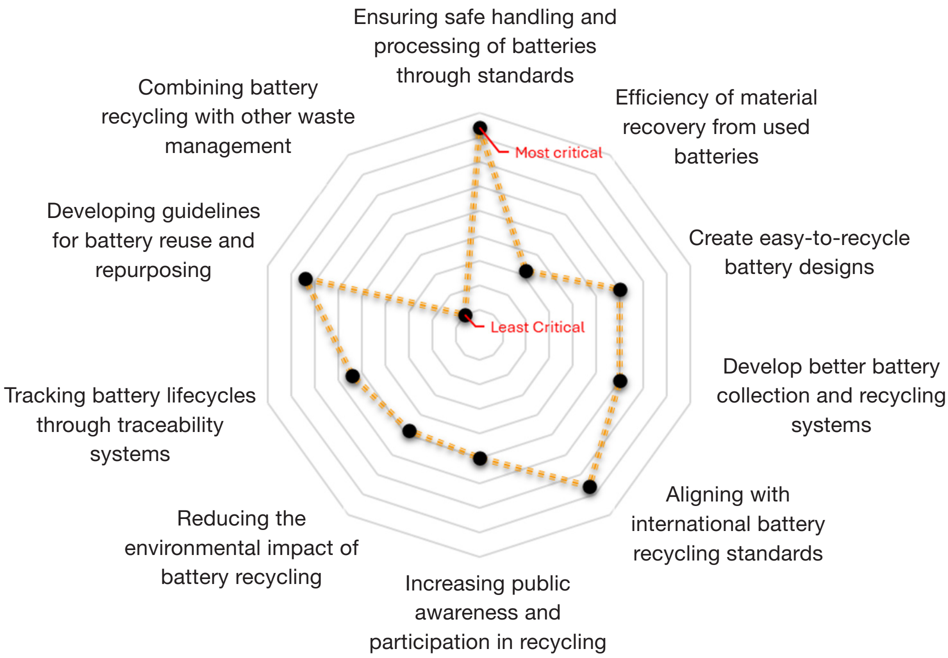
Sources:
Australian Battery Recycling Initiative (ABRI): https://stage.batteryrecycling.org.au/
B-Cycle: https://bcycle.com.au/
Department of Climate Change, Energy, Environment and Water: Home - DCCEEW

Advisory Group Survey

Q1. What are the most important elements in addressing future demands for battery reuse repurpose and recycle in Australia?

Survey results indicate that the most critical issues in addressing future demands for battery reuse, repurpose, and recycle in Australia are ensuring safe handling and processing of batteries through standards, need to develop guidelines for battery reuse and repurpose, and poor easy-to-recycle battery designs; and aligning Australian recycling standards with international standards.

Standards are crucial for ensuring both safety and alignment with international practices in the future of secondary battery reuse, repurposing, and recycling in Australia. Although these standards are still in the early stages of development, it is essential to establish guidelines for managing the second life of secondary batteries prior to recycling.



Q2. What other challenges does Australia face in expanding the circular economy for secondary batteries?

Operational Framework	“limited pathways for recovered materials back into batteries” “continued to extract virgin materials” “constantly trying to find markets or purposes for recovered materials
Regulatory Framework	“inconsistent or absence of regulations” “lack of harmonised regulations for facilities” “lack of battery directive framework”
Consumers / Manufacturers	“low consumer awareness” “perceived low value for money” “low consumer confidence” “lack of generator obligations schemes EPR” “lack of consumer awareness around reuse versus single use”
Standards	“inconsistent or absence of guidelines” “no design standards” “lack of harmonisation for battery storage and transportation” “design standards are not clear”
Economic Framework	“no financial incentives to collect or recycle” “limited funding to cover end-of-life activities” “low funding” “risk of ‘pay and throw’ schemes”

General Information

EU BATTERY DIRECTIVE 2023/1542

REGULATION (EU) 2023/1542 is a critical legislative measure adopted by the European Union to establish a comprehensive regulatory framework for batteries. The regulation aims to support the EU's transition to a more sustainable and circular economy, while ensuring the responsible management of battery materials and waste. The key elements of the regulation include:

1. **Sustainability and Safety Standards:** The regulation sets out strict requirements for the design, production, and disposal of batteries. It emphasises the use of sustainable materials, sets limits on hazardous substances, and mandates the use of recycled content. These measures aim to minimise the environmental impact and enhance the safety of batteries.
2. **Extended Producer Responsibility (EPR):** The regulation introduces obligations for producers to manage the entire lifecycle of batteries, from placing them on the market to their end-of-life treatment. This includes ensuring proper collection, recycling, and disposal of spent batteries.
3. **Carbon Footprint and Due Diligence**: Manufacturers must calculate and report the carbon footprint of their batteries, promoting transparency and accountability in the industry. Additionally, due diligence obligations are imposed on companies to ensure responsible sourcing of raw materials, addressing social and environmental risks.
4. **Collection and Recycling Targets:** The regulation sets ambitious targets for the collection and recycling of batteries, aiming to recover valuable materials and reduce waste. This includes specific targets for different battery types, such as portable batteries, automotive batteries, and industrial batteries.
5. **Information and Labelling Requirements:** The regulation mandates that batteries come with clear labelling, providing information on their composition, capacity, and environmental impact. This helps consumers make informed choices and supports the proper management of battery waste.
6. **Innovation and Circular Economy:** The regulation encourages innovation in battery technology and recycling processes, fostering the development of new solutions that enhance resource efficiency and sustainability. It also promotes the use of second-life batteries and the development of new markets for recycled materials.

BASEL CONVENTION

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal is a global environmental treaty adopted on March 22, 1989, and effective from May 5, 1992. It aims to protect human health and the environment from hazardous wastes by regulating their international movement and ensuring proper disposal.

Objectives and Scope

The Convention focuses on:

1. **Reducing Waste Generation:** Minimising hazardous waste production at the source.
2. **Promoting Safe Management:** Ensuring hazardous wastes are managed in an environmentally sound manner.
3. **Restricting Movement:** Controlling the export and import of hazardous wastes, particularly from developed to developing countries.
4. **Preventing Illegal Traffic:** Combating illegal trafficking through regulations and enforcement.

Key Provisions

1. **Prior Informed Consent (PIC)**: Exporting countries must get consent from receiving countries before shipping hazardous waste.
2. **Environmentally Sound Management (ESM):** Parties must manage hazardous wastes in a way that protects health and the environment.
3. **Export Restrictions:** Limits on exporting hazardous wastes to countries without proper disposal capacity.
4. **Notification and Documentation:** Detailed paperwork and notifications for transparency and traceability.
5. **Technical Assistance:** Promoting capacity building in developing countries for safe waste management.

Implementation and Compliance

The Conference of the Parties (COP) oversees the Convention, with administrative support from the Basel Convention Secretariat, which facilitates information exchange and capacity-building efforts.

Key challenges include:

1. **Illegal Trafficking:** Ongoing illegal hazardous waste trade due to economic incentives and weak regulations.
2. **E-Waste:** Managing the growing problem of electronic waste.
3. **Global Cooperation:** Strengthening international cooperation and enforcement mechanisms.

Future efforts will focus on enhancing compliance, addressing emerging waste issues like e-waste and plastic waste, and improving global cooperation.

Summary

The Basel Convention is crucial for managing hazardous wastes responsibly. By promoting environmentally sound practices and regulating international waste movements, it aims to protect human health and the environment. Continued global commitment is essential to address evolving challenges and effectively implement the Convention's goals.

Appendix 1. Advisory Group Members and Participants

Secondary Batteries – Reuse, Repurpose, Recycle Advisory Group Members	
Akaysha Energy	Duwayno Robertson
Enphase Energy	David Minchin
QUT	Josh Watts
Association for the Battery Recycling Industry (ABRI)	Katherine Hole
Battery Stewardship Council	Libby Chaplin
Waste Management and Resource Recovery Association of Australia (WMAA)	Gayle Sloan
Infinitev	Dickson Leow
National Transport Research Organisation (NTRO)	Charles Karl
National Transport Research Organisation (NTRO)	Paul Hillier
EnviroStream Australia	Marco Mitreski
Mendham Consultants	Frank Mendham

Secondary Batteries – Reuse, Repurpose, Recycle Participant Members	
Department of Industry Science and Resources	Paul Kamppi
Department of Industry Science and Resources	Veronica Heard
Department of Finance	Alan Balino
Department of Finance	Martin Jones