Australia and the Battery Ecosystem

A review of implications for stakeholders in
Australian battery manufacturing and recycling ecosystem
in accordance with the first
Australian Battery Recycling and Manufacturing Conference
Sydney 2023

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EXECUTIVE SUMMARY

Battery Manufacturers:

- Battery manufacturers are responsible for managing the end-of-life (EOL) phase of batteries.
- They can outsource EOL management or operate their own facilities for remanufacturing and recycling.
- Innovation in battery design is essential to facilitate repair and recycling processes and meet legal obligations.

Remanufacturers:

- Electric vehicle (EV) batteries reach EOL with 70% to 80% of initial functionality, with a focus on reusing components.
- Remanufacturers can extend battery life, reduce waste, and contribute to sustainability.
- Automation is crucial for scalability, but adapting to various battery types is a challenge.

Recyclers:

- Recyclers divide operations into Spines (dismantling and shredding) and Hubs (chemical processing).
- Collecting spent batteries is essential for raw materials, but supply will soon exceed capacity.
- Exporting intellectual property through joint ventures and licensing can fund recycling R&D.

Logistics:

- Logistics, particularly reverse logistics, is crucial but often overlooked in the battery ecosystem.
- Safety concerns and storage challenges need to be addressed.
- Innovations are expected to improve safety and storage practices.

Risks:

- Batteries pose fire hazards if used improperly, and cheap batteries not meeting safety regulations are a greater risk.
- Some battery materials can harm the environment if not managed correctly.
- Maintaining a positive public perception of batteries is crucial to avoid mistrust.

Insurers:

- Insurers face challenges in setting appropriate premiums for different sectors within the battery industry.
- Striking a balance between risk mitigation and economic viability is critical.
- Innovative risk-sharing models and cooperation with companies and government can help.

Regulations:

- Regulations are necessary to ensure the safe handling of batteries and materials.
- Import regulations must balance affordability and safety.
- Alignment with EU and US regulations can set high-quality standards.
- Regulators should engage with affected communities for informed decision-making.

Investments:

- The battery recycling industry requires significant capital investment.
- The National Reconstruction Fund supports battery recycling as part of the circular economy.
- Start-ups and early-stage companies play a vital role in innovation.
- Debt financing for mature companies is attractive due to ESG factors.

Gaps in the Discussion:

Important gaps include defining which part of the value chain should take place in Australia, understanding the interactions between recycling, new materials, and refining, and addressing the complexities of reverse logistics.

Introduction

In this newsletter we provide a comprehensive overview of the impacts and outcomes of the Australian battery manufacturing and recycling ecosystem. The foundation is the discussions and outcomes of the first Australian Battery Recycling and Manufacturing Conference, which was held in Sydney in 2023.

The world is moving towards a future of renewable energy and electrified transport. Electrical storage, such as lithium-ion batteries, will play a key role. This has implications for the lithium-ion batteries and materials needed. Battery demand is expected to rise from 700 MWh in 2022 to 4.7 TWh by 2030. Not only will production need to expand accordingly, but scarce materials such as lithium, nickel and cobalt will become critical to production. Nickel alone is expected to face a 55% shortfall by 2030 without new initiatives[1].

With global demand on the rise, our country's abundant resources are an important factor in the international supply chain. This surge in demand is not only economically promising, it also brings with it a huge responsibility to use our resources sustainably.

After all, a green turnaround in energy and mobility depends crucially on the environmental compatibility of the technologies used. A fundamental building block is the creation of a circular economy for LIBs that provides for reuse, repair and recycling of used batteries.

Australia's role in the emerging battery ecosystem is multifaceted, encompassing various activities from mining and material extraction to use and recycling.

Throughout this newsletter, we will highlight the different players in the battery ecosystem and classify the various outcomes of the Summit. We will also point out which aspects are still open and have not been addressed in the discussion so far.

We want to enable our readers to better understand and be inspired by this transformative era in Australian battery manufacturing.

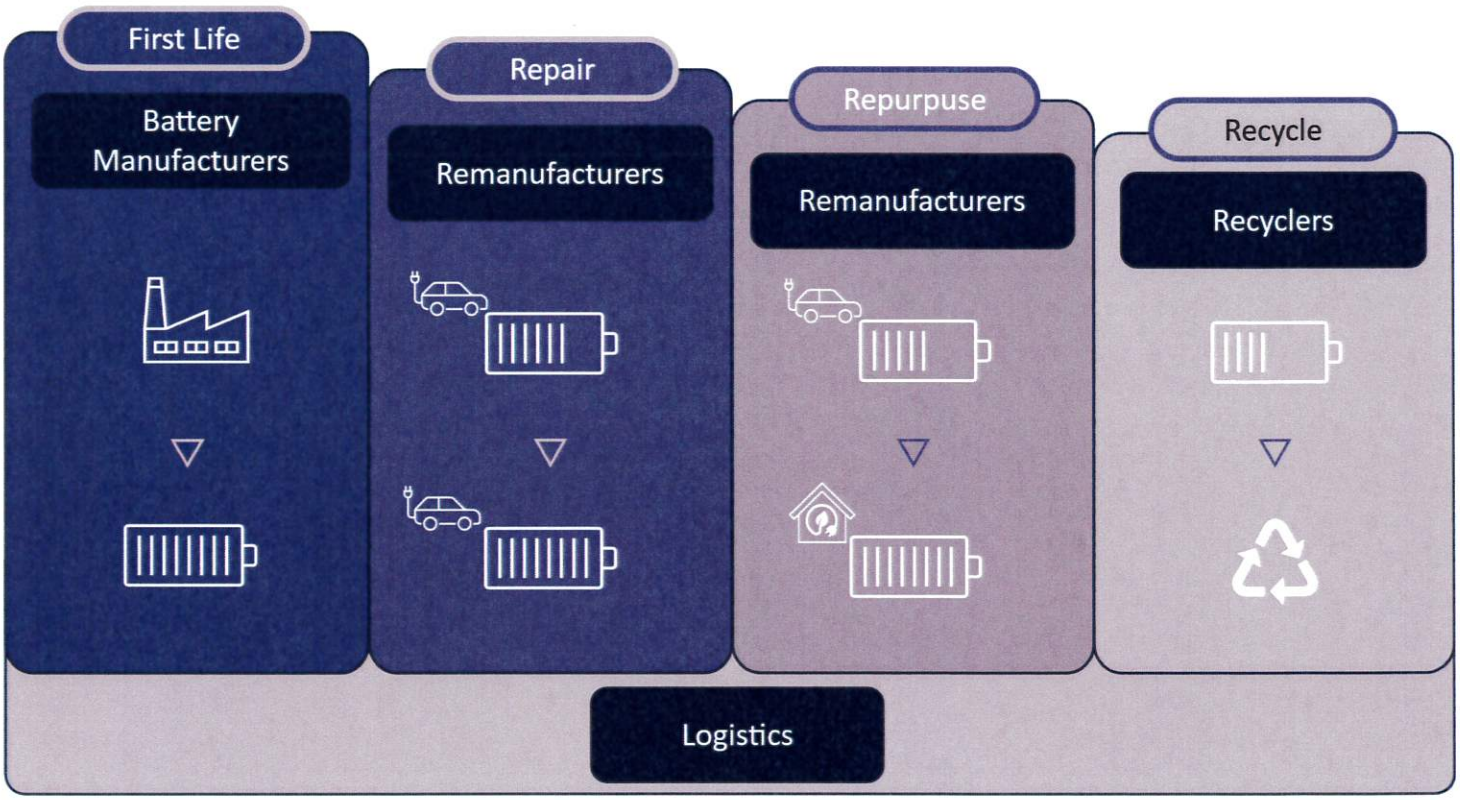

Figure 1: The Circular Battery Ecosystem based on Infinitev https://infinitev.au/

[1] McKinsey 2023, Battery 2030: Resilient, sustainable, and circular

Battery Ecosystem

The circular economy for batteries can be understood as a Battery Ecosystem with different Key Players including: Battery Producers, Remanufacturers, Recyclers, End-of-Life Logistics.

Battery Manufactures

- **Own the responsibility for end-of-life (EOL) management**
- **EOL battery management can be outsourced to partners and licensees**
- **operate their own remanufacturing and recycling facilities**
- **New battery designs must be developed to facilitate repair and recycling techniques.**

Battery manufacturers are responsible for managing the end-of-life (EOL) phase of their products. EOL management of batteries can be done in different ways. Manufacturers have the option of outsourcing this responsibility to partner companies that specialise in EOL management or to recycling companies to which they transfer the environmentally sound disposal and recycling of spent batteries. Alternatively, they can operate their own facilities for EOL management.

With the clearly foreseeable volumes of future EV batteries reaching end-of-life, the need for battery manufacturers is clear: innovation in battery design is paramount. New battery designs need to be developed to facilitate repair and recycling and to enable industrial automation of these processes. These designs should incorporate techniques and features that enable disassembly and recovery of recyclables on a scalable scale and promote sustainable recycling of batteries. The introduction of such innovations ensures that manufacturers meet their legal obligations and also contributes to a circular approach to battery production and use.

Remanufactures

- **EV battery reaches EOL when it has 70% to 80% of original functionality**
- **Functionality determined by weakest part, leading to large proportion of reusable components**
- **Large opportunities to reduce landfill and retain value of working parts**
- **Automation and robotics will be critical to scale, but is key challenge due to enormous product diversity.**
- **Over the next few battery life cycles, warranty estimates are reasonable.**

The end-of-life (EOL) landscape of electric vehicle batteries presents a unique opportunity for remanufacturers. EV batteries have reached the EOL stage when they still have between 70% and 80% of their original functionality. This functionality is not just a single parameter, but is largely determined by the weakest part of the battery system, which often means that a significant proportion of the components can be reused.

This is where there is significant potential to reduce landfill impact and retain the value of fully functional parts. The art of remanufacturing is to use testing procedures to determine the potential of each battery and its components and to determine the next steps.

This can be remanufacturing fontinating components into batteries for the same automotive application, repurposing where functional battery components are assembled for less demanding applications such as battery storage systems (BESS) or sending the components for recycling for material recovery. By recovering and refurbishing reusable components, remanufacturers can extend the life of these batteries, reduce waste and contribute to a more sustainable future.

However, the path to greater sustainability and efficiency in battery remanufacturing comes with a number of challenges. Due to the enormous variety of EV batteries on the market, remanufacturing processes need to be automated and robotised to achieve economies of scale and efficiency. One of the biggest challenges is adapting the

automation to the different battery types, sizes and configurations.

Recyclers

- **At the moment, recyclers pay for spent Batteries in order to have enough raw materials.**
- **This is expected to change in about 5 years when the supply of old batteries exceeds the supply of recycling capacity.**
- **Exporting intellectual property through joint ventures and licensing is another viable way to fund R&D in recycling technologies in Australia.**

Recyclers play a central role in achieving a circular economy for batteries, and their operations can be divided into two main functions: Spines and Hubs. Spines are responsible for dismantling and shredding the battery packs to recover the valuable black mass, which contains rare and valuable materials such as lithium, nickel, cobalt, manganese or graphite. The hubs, on the other hand, are mainly concerned with the chemical processing of this black mass, recovering the materials through hydrometallurgical or pyrometallurgical processes. The better the mechanical separation of the materials in the spines, the higher the yield and quality in the hubs, which has a positive impact on the LCA of the overall process.

A large proportion of the EV batteries produced are still in their first life cycle on the road, so recyclers are currently pursuing a strategy of "collecting all the batteries they can get". This approach is a result of the need to collect sufficient raw materials for the maintenance of operations.

Over the next five years, however, the situation will change fundamentally. It is expected that the supply of spent batteries will significantly exceed the available recycling capacity. (Source) This period of transition will require strategic adjustments in the recycling industry to match the influx of spent batteries with processing capacity. Processing capacity will need to be scaled up, with manual processes kept to a minimum.

In addition, recycling companies in Australia have the potential to expand their influence globally through the export of intellectual property. Through joint ventures and licensing agreements, they can share their advanced recycling technologies with international partners. This not only encourages collaboration, but is also a viable way to fund further research and development initiatives in the recycling sector. With this forward-thinking approach, recyclers can position themselves as pioneers for a sustainable future of battery recycling in Australia and beyond.

Logistics

- **Not much thought has been given to the logistics so far**
- **Acknowledgement that backward logistics is backbone of eco system**
- **Has to deal with safety concerns e.g. thermal runaway, dangerous goods classification**
- **Storage on recycling facilities is a threat**
- **Innovation is to be expected**
- **Gap in the conversation**

In the discussion on the circular economy of batteries, logistics has not played a role so far. While the spotlight has mainly focused on the dismantling and material recovery processes, the crucial role of logistics in the ecosystem is becoming increasingly clear.

The recognition of the importance of reverse logistics has reached industry representatives in Australia. The scalability, security and reliability of this logistics network are crucial for a successful battery recycling network.

The insufficient volumes of spent batteries that need to be transported hinder innovation and business models in this area, but there is no doubt that this situation will change in the next five years.

Innovations are expected to play a central role in overcoming these logistical challenges. Technical innovations that make the risk of batteries more manageable could make some of the transport safer and therefore easier. They will also lead to new safety protocols and enable storage practices needed for a scalable recycling industry.

However, there is a clear gap in the current discussion on the logistics of battery recycling. It is critical that stakeholders and industry broaden their perspective to encompass the full lifecycle of battery recycling, with

logistics playing a central role. By addressing these logistical challenges and driving innovation in this crucial aspect of the recycling process, the industry can further advance its sustainability goals and ensure a safer and more sustainable future for battery recycling.

Risk

Batteries and Materials

- **Batteries are a fire hazard if used incorrectly or deformed.**
- **Cheap batteries that do not comply with safety regulations pose a greater risk.**
- **Some materials used in LIBs can be harmful to the environment and human health if not properly managed.**

Public perception

- **The public perception of batteries could change from a green product to a dangerous one**

The public perception of lithium-ion batteries has long been seen as a symbol of green innovation and sustainability. As incidents continue to hit the headlines, the collective perception of batteries as an environmentally friendly and sustainable technology is increasingly being challenged. There is a risk that public perception will shift from an environmentally friendly product to a potentially dangerous one. Ecosystem stakeholders agree that major incidents involving lithium-ion batteries must be avoided in order not to risk public mistrust.

Whether it is the mining and refining of battery materials, the handling of old batteries or the recycling of batteries, the battery industry relies on the public's favour.

Insurer

- **Gap in the debate on how insurers should calculate premiums to make the business of batteries economically viable.**
- **What premium to charge recyclers, remanufacturers, reverse logistics?**
- **Remanufacturers are required to provide a warranty for remanufactured batteries, but there is little empirical data on the behaviour of remanufactured batteries.**

For insurers, the complex landscape of battery-related businesses such as manufacturers, recyclers, remanufacturers and reverse logistics providers presents a number of challenges in setting appropriate premiums. Finding the right balance between mitigating risk and ensuring the economic viability of these businesses is critical.

One of the most important considerations for insurers is deciding what premium rates should apply to these different sectors within the battery industry. Each sector has its own risks and specifics. For example, manufacturers have to pay for the disposal and end-of-life strategies of their products. There is the question of the cost of outsourcing remanufacturing or recycling and the expected lifetime of the batteries.

Recyclers, for example, collect and process spent batteries, which can pose potential safety and environmental risks. The risk of environmentally hazardous substances entering the environment needs to be assessed, as does the fire risk associated with handling and storing spent batteries. There is also a risk of fires or the release of environmentally hazardous substances in transport accidents during reverse logistics. Remanufacturers, in turn, have to provide warranties for the repaired batteries, but there is little empirical data on the long-term behaviour of these remanufactured batteries.

However, there is a large gap in the discussion on how insurers should calculate premiums to support the economic viability of battery companies. It is important to strike a balance between affordable insurance cover and ensuring the economic viability of businesses. This is all the more true because some companies, such as remanufacturers or reverse logistics companies, have little track record due to their young stage of development. Insurers could explore innovative risk-sharing models, incentivise safety measures and sustainable practices, and encourage cooperative dialogue with companies and the government.

In summary, the battery industry is a dynamic environment for insurers that requires a nuanced approach to risk assessment and premium calculation. Filling this gap by actively engaging with battery companies, government and adapting insurance strategies to support economic viability can contribute to a sustainable and safe ecosystem for all stakeholders.

Regulations

- **Ensure safe handling of batteries and their components.**
- **Which batteries should enter the country?**
- **Align with EU and US regulations to prevent poor quality batteries entering the country.**
- **Engage in dialogue with the Australian community affected by recycling facilities.**

Policy makers have an inherent responsibility to manage the above risks, and their functions cover various aspects of safety, sustainability and public welfare.

First and foremost is the task of ensuring the safe handling of batteries and battery components by adopting regulations for handling, transport, storage and disposal that meet the requirements for lithium-ion batteries.

In particular, the regulatory authorities will have control over which batteries can be imported into the country. The trade-off between affordable technologies for the public and safety is a delicate one. Preventing the import of inferior and potentially dangerous products that do not meet certain safety requirements is one way to protect the public. It also promotes innovation in the industry by encouraging the use of high quality batteries.

It makes sense for Australia to seek alignment with regulations such as those of the European Union (EU) and the United States (US). These institutions are leaders in setting recycling rates for LIBs as well as safety regulations. The concern is that batteries from these markets will not be able to compete with cheap, unregulated batteries in the future. This alignment will help prevent inferior batteries from entering the Australian market by using the collective knowledge and experience of these global institutions to set high quality standards.

Finally, regulators need to have an open and productive dialogue with the Australian community affected by the hazards of spent batteries and recycling facilities. Unlike refineries, such facilities may not be located in Australia's remote areas, but may be linked to populated areas due to transport costs and proximity of workforce. Public awareness, education and participation are essential components of responsible regulation. By engaging with affected communities and listening to their concerns, regulators can ensure that safety measures are effective and that the public's voice is heard and respected in shaping the regulatory landscape.

In summary, regulators have an important responsibility to steer the battery industry towards safety, sustainability and innovation, while maintaining a positive public perception. By focusing on safety standards, import regulations, international harmonisation, informed dialogue on recycling and public engagement, regulators can play a critical role in shaping a future where batteries are both technologically advanced and environmentally sustainable.

Investments

- **The recycling industry is characterised by high investment costs.**
- **National Reconstruction Fund advocates support for circular economy of lithium-ion batteries**
- **Thriving field for emerging, early stage and start-up companies**
- **In addition to venture capital and joint ventures, government grants play an important role in meeting the high capex needs of early-stage companies.**
- **Attractive debt market for mature companies due to government guarantees and positive ESG impact**

Investment in the battery recycling industry is capital intensive. This is due to the equipment required and the resulting high CAPEX. However, investment in this area has the advantage of being in the public interest and the need is clearly predictable.

At a national level, Australia's commitment to promoting a circular economy for lithium-ion batteries is supported by the National Reconstruction Fund. Part of the A$15 billion fund is earmarked for the battery industry's circular economy, the NRF chairman confirmed.

The recycling sector is fertile ground for emerging early-stage companies and start-ups. Spin-offs from research projects and direct investment in patents and processes are a critical first step. Scaling up to industrial scale is a major challenge given the high investment needs.

Venture capital and joint ventures play an important role in providing early stage companies with the capital and know-how needed for commercialisation. In addition, government subsidies are an important component for these companies to make initial investments in plant and equipment.

The battery recycling industry is an attractive market for debt financing, especially for mature companies. The presence of government investment and the positive influence of environmental, social and governance (ESG) issues related to sustainable battery recycling practices make these companies attractive to debt investors.

In summary, the circular economy for batteries, while characterised by high investment costs, holds great promise as a cornerstone of sustainable battery management. With the support of initiatives such as the National Reconstruction Fund, government subsidies and growing interest in green debt, the recycling sector is well positioned to drive innovation, environmental responsibility and economic growth in the evolving battery ecosystem.

Gaps in the Discussion

- **What part of the value chain will take place in Australia?**
- **How will recycling affect the refining of materials?**
- **How will backward logistics be managed?**

The overall picture of the Battery Conference was coherent and many aspects were highlighted. In addition, there were limited areas of disagreement between representatives of the recycling and manufacturing industries, research, finance, regulators and service providers.

However, there were critical gaps in the discourse on the battery industry and its sustainability that require further attention and research.

The key gap that needs to be addressed is which part of the value chain should ideally take place in Australia. While the country claims its place in the global mining of materials for the battery industry, the debate on aspects of refining, battery manufacturing and recycling is still ongoing. How much material should be recovered in Australia? Just the batteries used in the country, or is it a question of the standards by which the materials are mined?

This raises the further question of how recycling practices will affect the mining and refining industries and their strategic planning. Battery recycling is a key factor in minimising waste and maximising resource efficiency. However, the synergies and potential conflicts between mining, refining and recycling processes remain largely unresolved. A comprehensive understanding of these interactions will enable the development of strategies that encompass both recycling and refining processes, creating an integrated battery ecosystem.

Finally, we always assume a functioning reverse logistics system, which is a neglected facet of the battery ecosystem. While we are deeply involved in battery production, recycling and end-of-life management, there is a noticeable gap in our understanding of the complex web of processes that make up reverse logistics. It is imperative that this gap is addressed to ensure efficient and sustainable transport, collection and treatment of end-of-life batteries, which are the backbone of responsible recycling and resource recovery.

In summary, these gaps in our discussions on the localisation of the value chain and the interactions between recycling, new materials and reverse logistics are critical to developing a holistic understanding of the sustainability of the battery industry. Filling these gaps will enable us to develop more informed policies and actions that balance economic growth, environmental responsibility and technological advancement in the battery sector.