

Lithium Ion Batteries in the Circular Economy – New Developments From CSIRO





I would like to begin by acknowledging the [Traditional Owner/s name] people as the Traditional Owners of the land that we're meeting on today, and pay my respect to their Elders past and present.



Growth of Battery Capacity Demand





Competition LIB – NMH – NiCd







Cost of Production



Based on NCM811 cells with 80Ah and battery pack with 240 cells at a plant with battery pack annual capacity of 100,000 units. Note:

Cathode is largest cost contributor Changes mainly due to processing costs





Source of batteries

Supply of key materials

What does this mean for GHG emissions

How do we deal with the emerging waste stream, do we have an EoL strategy ??





Projected EoL Lithium ion batteries in Australia:

~ 100,000 tonnes by 2034-35.

SOURCE: Battery stewardship Council



Supply of LIBs







GHG emissions per kWh NMC battery

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Cell Chemistry	Spec. Energy Wh kg ⁻¹	Total Materials GHG-e kg CO2e kg ⁻¹	Manufacturing GHG-e kg CO2e kg ⁻¹
NMC	210	4.4	3.0
NCA	190	4.1	4.1
LFP	100	3.7	2.9
LMO*	114	5	1

Data for cylindrical cells except *

NMC: Nickel Manganese Cobalt Oxide

NCA: Nickel Cobalt Aluminium oxide

LFP: Lithium Iron Phosphate

LMO: Lithium Manganese Oxide



How beneficial is LIB Recycling?

GHG-e and E-consumption

- •Pyrometallurgy net Increase
- •Hydrometallurgy net Decrease
- •Direct cathode recycling net Decrease
- •Cathode chemistry decides







	den	nand/Mt	production/Mt
	2020	2030	2020
Li	0.380	2.3 (6 x)	0.41
Со	0.021	0.17 (8 x)	0.14
Ni	0.1295	1.45 (11 x)	2.5
Cu	0.319	2.38 (7 x)	20.0
AI (foil)	0.194	1.42 (7.5 x)	16.5
Nat. Gi	r <0.4	1.77 (4.4 x)) 0.96

Sources: Roskill 2022, US Geological Survey, IEA, Int. Aluminium









Demonstration Discharging Batteries



- Demo for various packs, i.e. 48V unit, total of 0.6kWh removed
- Energy can be fed into grid or facility mains
- Unit reached < 0.1 V</p>
- 5 kWDemo built with common power electronics and hardware
- Scalable depending on facility requirements
- Industry Partner Project







Brisbane (Sept 2018)

- EoL LIBs can contain 50-80% of initial energy
- Damage or short circuit create fire hazards
- Multiple different form factors complicate this energy removal

Demonstration Battery Second Life / Reuse

- Real-life demonstrations showing viability can dissuade consumer concerns
- Developed versatile battery management system (BMS)
- System is battery chemistry agnostic
- Industry Partner Project Demo: EV EoL batteries
- PV into battery and then grid export
- Large pack development for office/commercial load support with PV input



Standards for LIB packs EoL @ 70-80% capacity

...likely to be fit for other purposes after "health check"

...but true hurdles, Certification Regulations Warranties



Demonstration Battery Shredding

- 1st Demo of its kind in AUS
- Custom built for High Safety operation
- Dry shredding
- Total nitrogen atmosphere
- Optical Chamber monitoring
- IR Temperature monitoring
- Interchangeable hopper & receiving vessels
- Can be used as experimentation platform







Optical and Thermal Monitoring of process









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Demonstration Lithium Salt Recovery



Component	Spot Price 7/20 US\$/t	Spot Price Nov/21 US\$/t
Electrolyte solution	132000	150000
LiPF ₆	7400	59300
Li ₂ CO ₃	7250	28000
LiOH	9500	30000
Nickel	13070	20900

Sources: Metals, Trading economics LiPF₆, OilChem China, Electrolyte Solution, Alibaba





✓ Patent entered National Phases

- ✓ Numerous experiments conducted
 - Process Variables tested (up to 30 g lab scale):
 - Conditions for effective crystallization
 - Process Temperature
 - Recovery from partially decomposed electrolyte

Phase and Product Analysis

- Identification of components in liquid phases
- Confirmation of Li-salt composition (NMR, EA)
- Recovery yield >> 80% (based on 1M Electrolyte)

✓ Battery testing

- Use of commercial electrode materials
- Rate testing

✓ Techno-economic Analysis





Thank you

Energy

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