Unlocking Battery Circularity

Bridging Gaps Across the Value Chain

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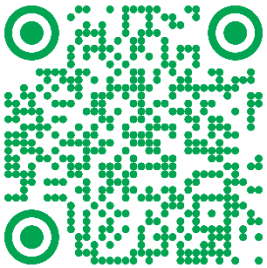
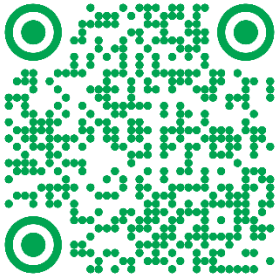
Standards &
Engagement

Battery Circularity Research: Landscape Analysis & Enterprise Survey





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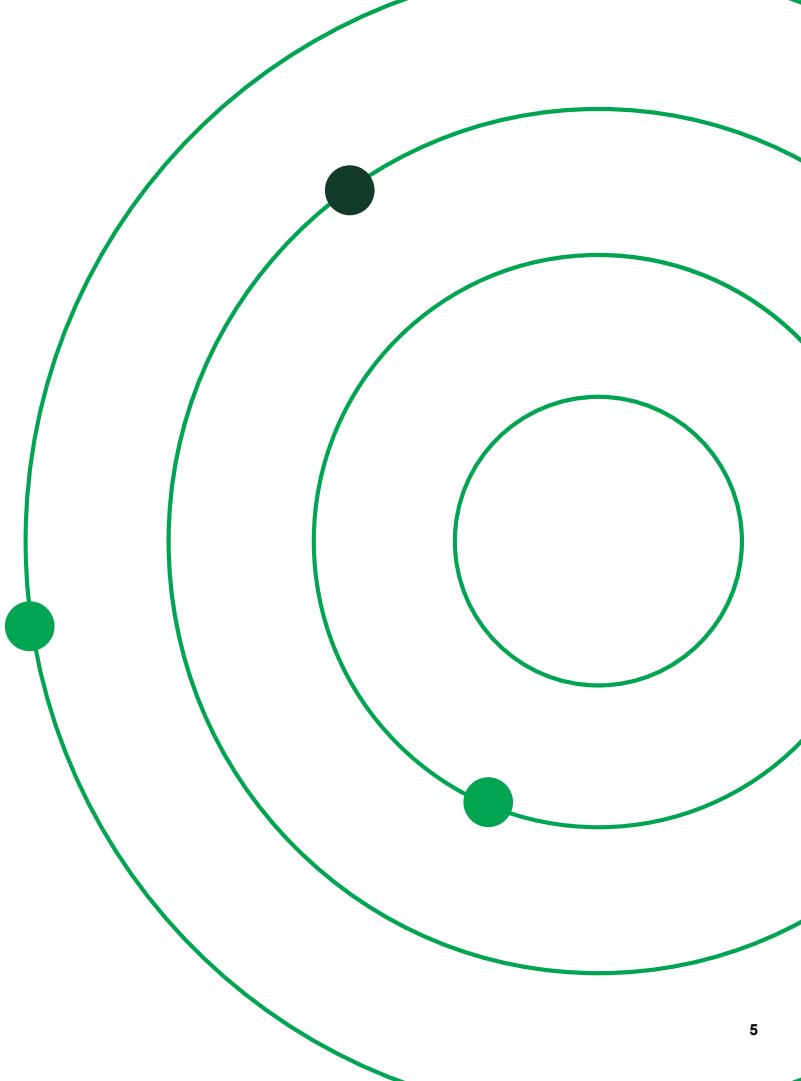
Prepared for UL Standards & Engagement by Wood Mackenzie and NewtonX

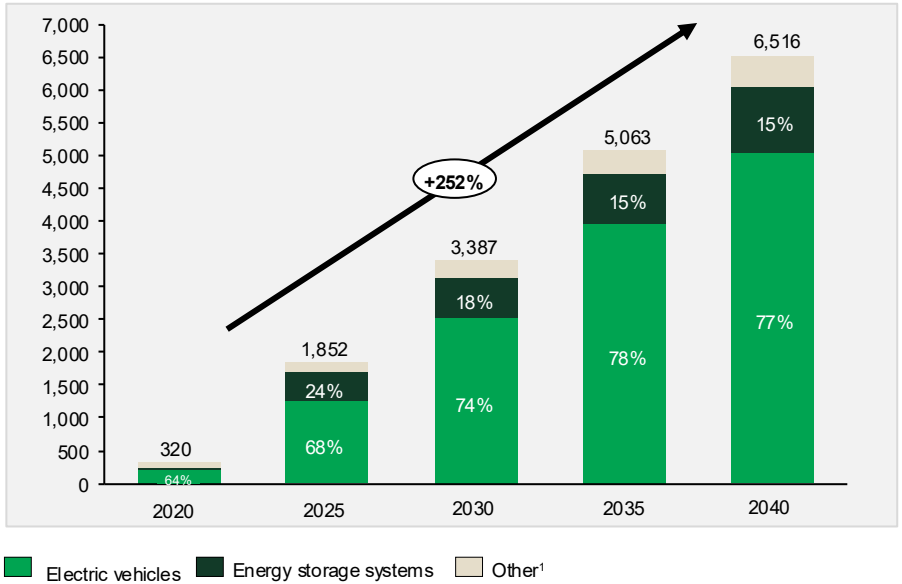
Battery Recycling/ Repurposing Demand



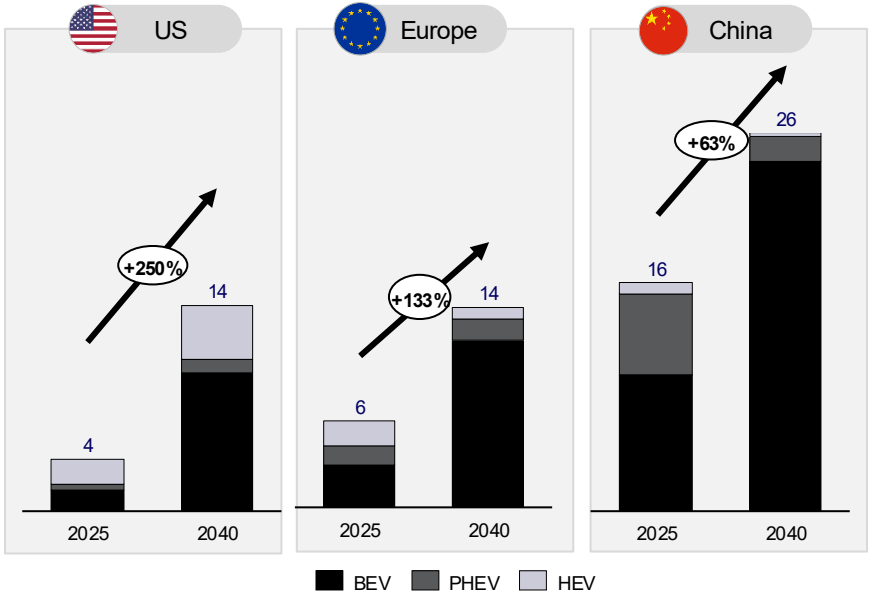
Lithium-ion battery demand is forecasted to increase 252% from 2025 to 2040, driven by EVs and ESS

Global EV sales have surpassed 26 million in 2025, and a growing share of these vehicles will reach end-of-life in the coming years, as their batteries no longer meet the performance required for continued use in EVs

Global Lithium-Ion Battery Market Size by End-Use (GWh)



EV[2] Sales by Region (Million)

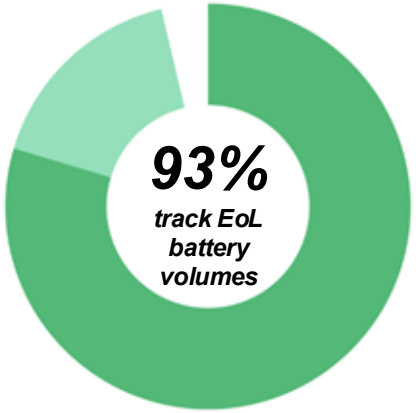


Source: Wood Mackenzie | Note: [1] Others include portable electronics, power devices, motive products [2] BEV=battery electric vehicle, PHEV=plug-in hybrid electric vehicle, HEV=hybrid electric vehicle

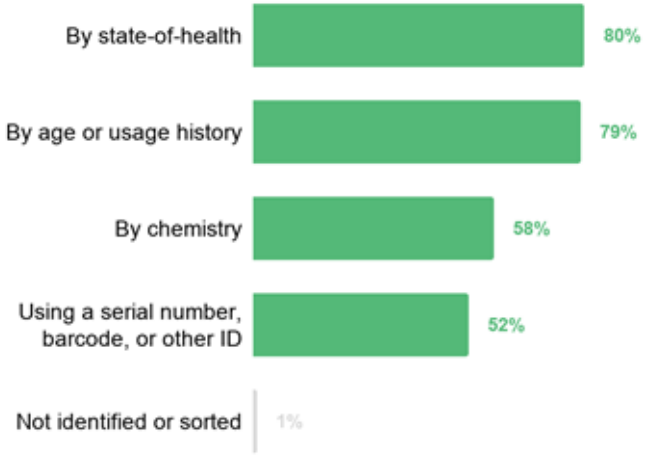
Battery volumes are growing but experts track based on spotty state-of-health data.

These handlers are sorting by health and use today, but the importance of communicating each battery's health and usage data downstream will become more critical as volumes increase.

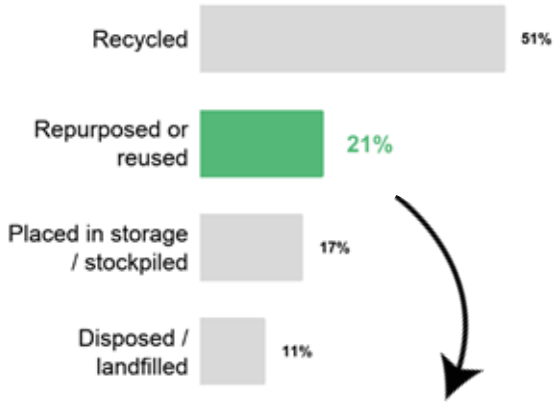
END OF LIFE TRACKING



SORTING PROCEDURE



END OF LIFE DESTINATIONS



42% say the number of batteries repurposed will increase in the next year.

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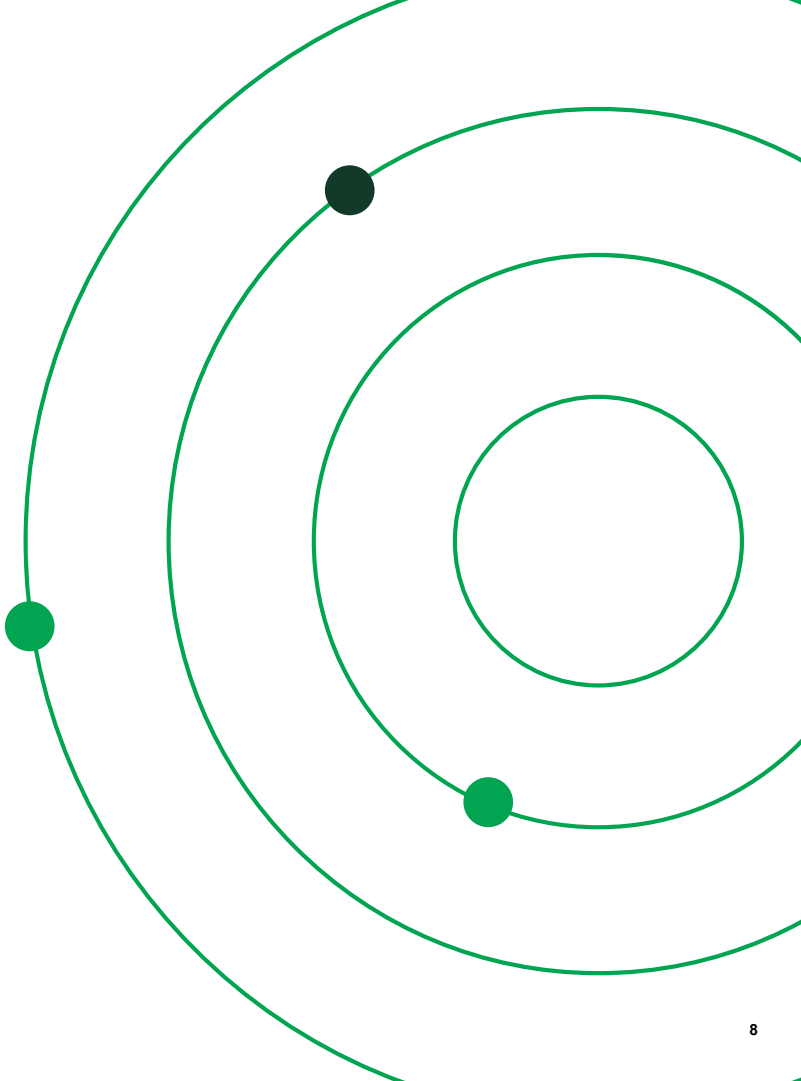
Source: NewtonX ***Note:*** *No significant difference between North America and EU emerged.*

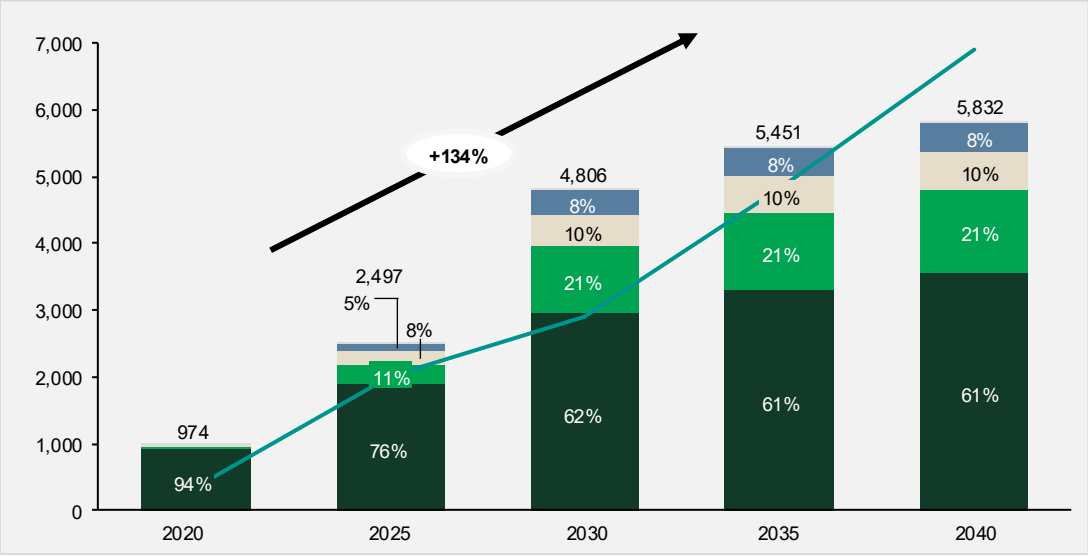
Recycling Capacity vs Demand



Global lithium-ion battery recycling capacity is anticipated to scale 134% through 2040

After 2030, more than 60% of global capacity will be based in China, with Europe and North American capacity to reach a combined ~30% of global total capacity in all case scenario with additional pipeline projects

Global Li-Ion Battery Recycling Capacity[1] (kt BME[2])



Key Points

- **China's dominance in EV manufacturing and battery supply chains** has enabled it to establish recycling capacity early and at scale
- **Europe and North America are now accelerating capacity buildout**, supported by policy incentives, localization strategies, and projected growth in EOL volumes
- **Other Asian markets lag behind China**, primarily due to significantly smaller domestic EV markets and limited feedstock availability
- **Announced recycling capacity significantly exceeds available feedstock volumes**, indicating aggressive capacity build-out ahead of the EOL wave

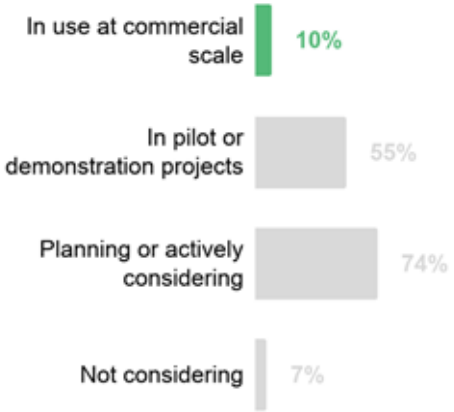
Source: Wood Mackenzie | Note: [1] All cases; [2] Black mass equivalent

Second-life battery usage at scale is limited; increasing confidence in SoH and usage history will address key roadblocks to second-life adoption.

Standardized tracking procedures could address the uncertain safety risk posed by these batteries and increase confidence inscaling their use.

SECOND-LIFE ADOPTION STAGE

% of orgs at each stage



SPECIFIC BARRIERS TO ADOPTION

% of orgs who say each is a main risk preventing broader use

Limited SoH, usage, or traceability data	**56%**
Fire or thermal runaway risk	51%
Performance uncertainty over remaining life	48%
Lack of clear standards or certifications	47%

IMPROVING DATA COULD MOVE THE NEEDLE

7% **Only a small number are completely confident that current regulations ensure they are safe**

49% **Say their confidence would increase with standardized data on SoH & usage history**

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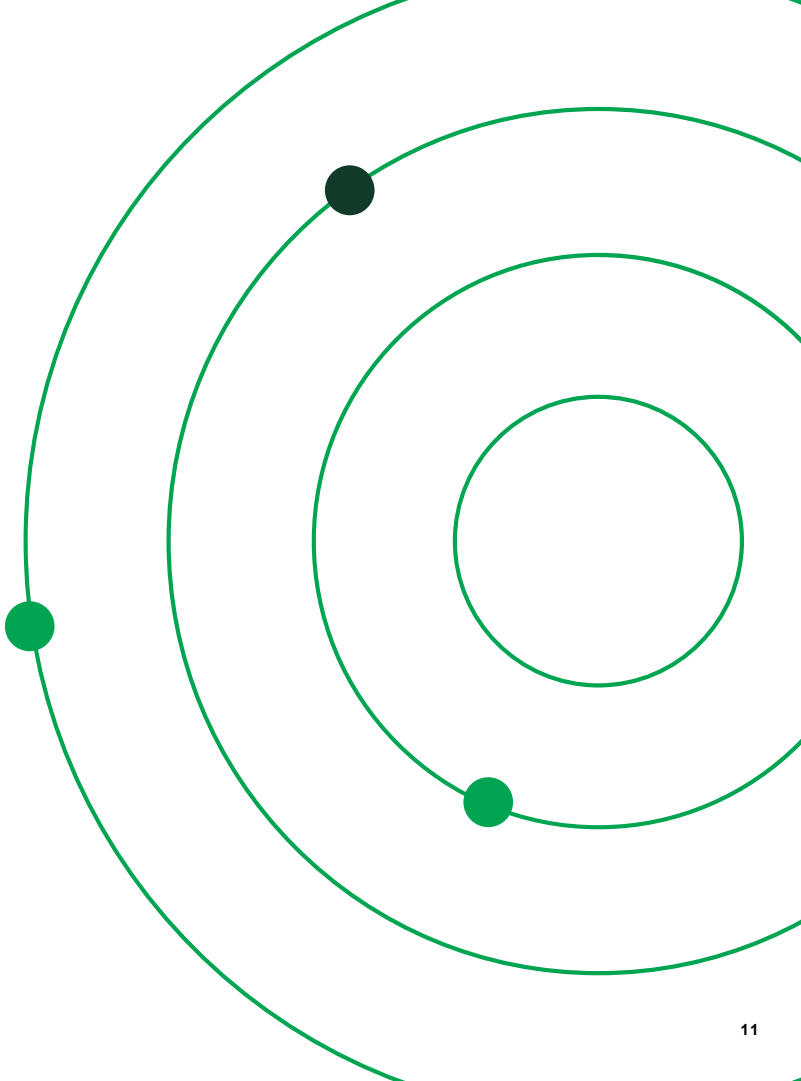
Source: NewtonX **Note:** *No significant difference between North America and EU emerged.*

Battery EoL Scaling Barriers



Structural gaps across the battery value chain as the industry scales

The existing regulations and management practices haven fallen short of preventing the increasing number of fires within recycling, exposing systemic gaps in traceability, accountability, and standardized handling practices

Structural Challenges in US Battery EOLM System

Fragmented Flows & Traceability

- No national system to track end-of-life batteries across the value chain
- Visibility drops once batteries leave OEM or fleet ownership
- Battery condition, chemistry, and state-of-charge are often unknown at handoff
- Some batteries are diverted to unlicensed dismantlers or informal processors



Diffused Accountability & Regulatory Gaps

- No consistent federal Extended Producer Responsibility (EPR) framework
- Responsibility often shifts between OEMs, logistics providers, and recyclers
- Hazardous waste classification varies across states
- Permitting requirements remain unclear for emerging recycling facilities

Storage, Logistics & Processing Safety Risk

- Damaged or partially charged batteries entering storage and waste streams
- Many facilities not designed for lithium-ion thermal runaway risks
- Inconsistent practices for discharge, segregation, and labeling
- Mechanical pre-processing can trigger short circuits or fires

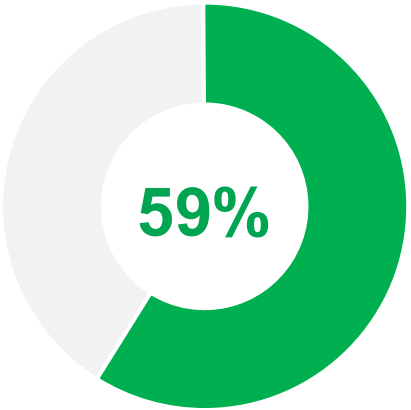
Environmental & Economic Fragility

- Volatile metal prices compress recycling margins
- Limited EOL battery availability today; recyclers rely heavily on production scrap as feedstock
- Potential environmental risks (air emissions, wastewater, particulates)
- Growing community scrutiny around siting and operations

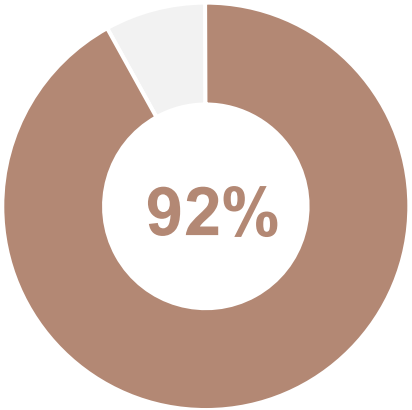
Trust and operational efficiency for battery handlers is rooted in clear battery end-of-life classification.

Despite high familiarity with local rules, a lack of clarity around repurposing eligibility is stalling progress.

REGULATORY KNOWLEDGE



Are familiar with the specifics of local regulation



Say those regulations are NOT very clear about when batteries should be repurposed or reused rather than recycled

POTENTIAL HIGH-IMPACT POLICIES

% of orgs who say each would make their EoL operations easier.

SoH testing at retirement	**60%**
Third-party safety certification	59%
Digital battery passport requirements	58%
Producer responsibility / take-back mandates	56%
Classification at end-of-life	55%

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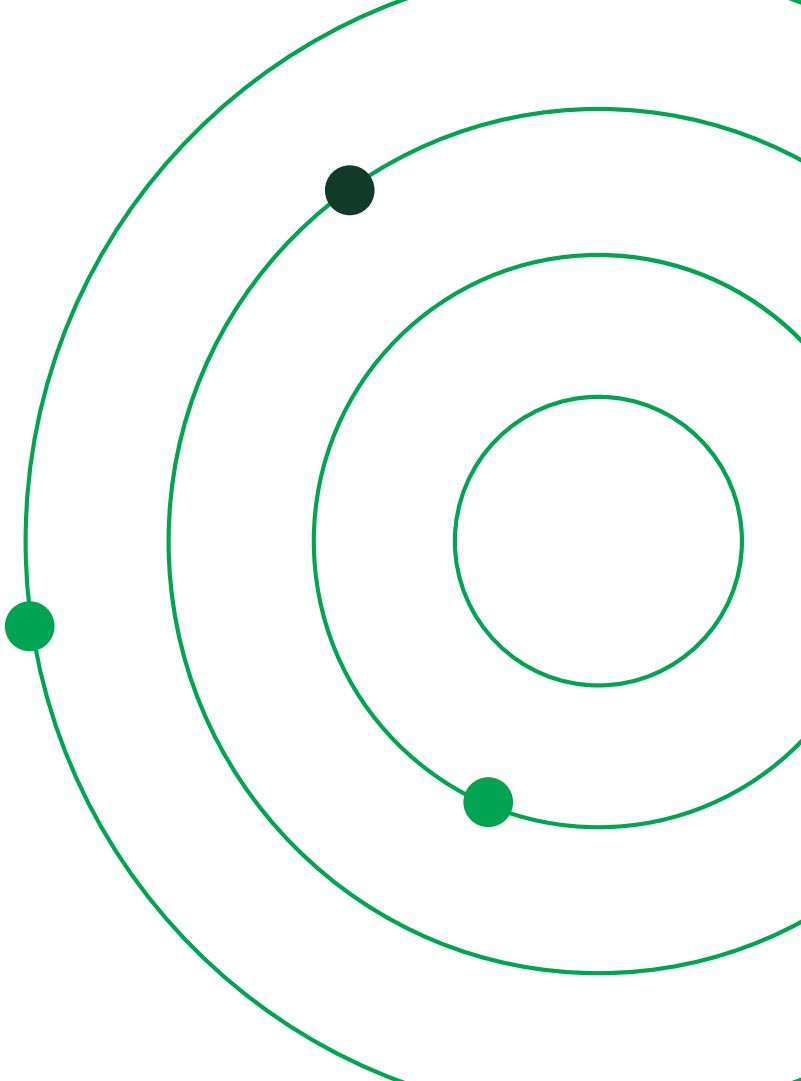
Source: NewtonX **Note:** *No significant difference between North America and EU emerged.*

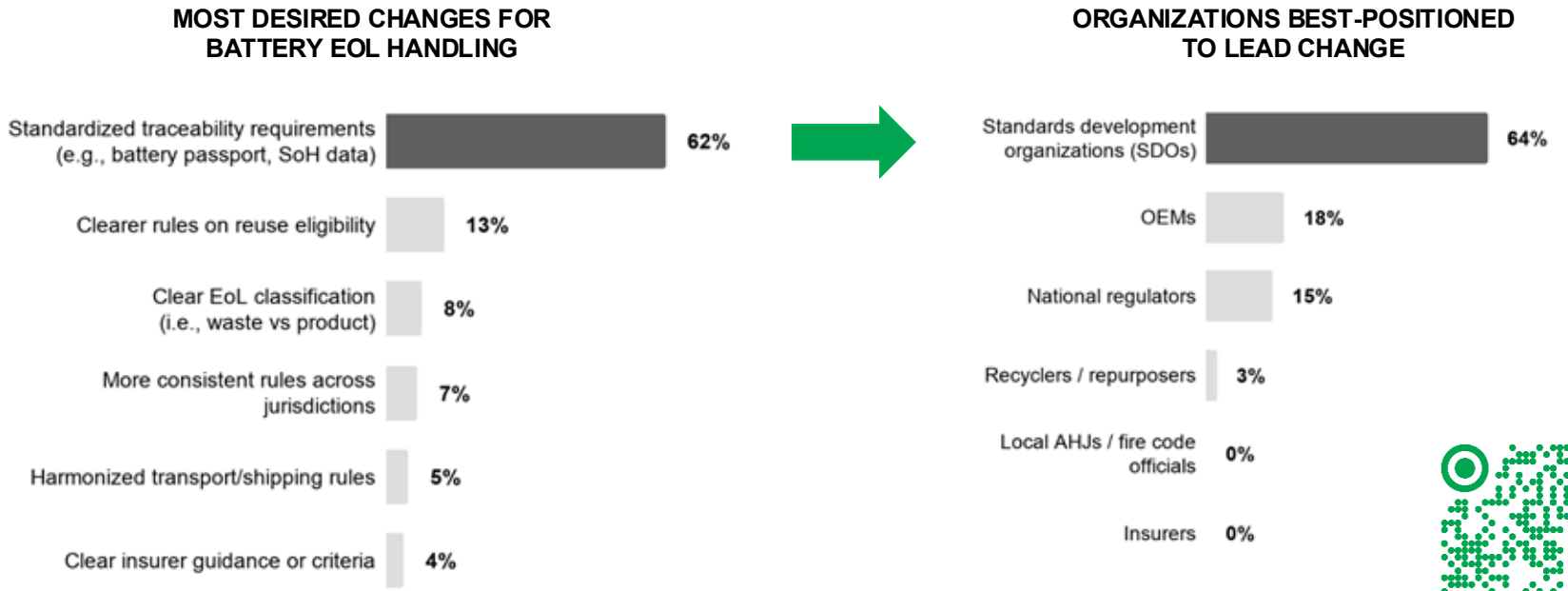
Advancing Battery EoL Value Chain



Standards & Engagement

Standardized traceability frameworks for EoL batteries demanded by growing industry.

Experts are eager for greater standardization and SDOs are best-positioned to deliver. Governments and organizations who have a monetary stake in the industry are less trusted to develop universal standards.



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Source: NewtonX. ***Note:*** *No significant difference between North America and EU emerged.*

ULSE is well-positioned to shape the US battery recycling/repurposing value chain ecosystem[1]

…. However, voluntary consensus standards, i.e. ***UL 1974, Evaluation for Repurposing or Remanufacturing Batteries*** *&* ***UL 3601, Measuring and Reporting Circularity of Li-ion and Other Secondary Batteries****, must evolve to scale solutions*

	Operational Standards	Traceability	Facility Design	Regulatory Alignment
System Gap	**Inconsistent Safety Practices** *Operational procedures for battery handling, discharge, and pre-processing vary across facilities, increasing safety risks*	**Limited Lifecycle Visibility** *No national system for tracking EOL batteries, and battery condition and documentation are often unclear at transfer points*	**Uneven Infrastructure Readiness** *Recycling and storage facilities are not consistently designed for lithium-ion battery hazards and thermal runaway risks*	**Fragmented Regulatory Interpretation** *Regulatory interpretation and permitting approaches vary across jurisdictions, creating uncertainty for operators and regulators*
ULSE Current Instrument	**UL 1974** exists as the standard specifically for evaluating repurposed and remanufactured batteries, but **adoption has been slow due to high testing burden**. It appears designed for safety rigor before economic scalability	**UL 3601** (circularity framework) exists, but is **not a lifecycle tracking system**. **UL 1974** requires repurposer to gather data from each incoming battery, but OEM have **no obligation** to share it, so they have to rely on **expensive/timely testing**	ULSE has deep facility-related standards (UL 9540(A)/1973) for battery storage but **not for recycling/disassembly**	**UL 1974** is **voluntary and only mandatory** when someone wants to put **repurposed battery into ESS** which requires UL 9540 & UL 1973. For **recycling operations themselves (black mass production, hydrometallurgical processing), there is no fire code requirement**

Note: [1] Preliminary hypotheses based on initial analysis; Further technical review and stakeholder input will be required to refine potential standards development areas

Standards & Engagement

Thank you



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