EV Batteries: Where We Are and Where We Could Be Going

From vehicles to energy asset to circular infrastructure

ELECTRIC VEHICLES VISION GROUP

WORLD RESOURCES INSTITUTE | POLSKY CENTER FOR THE GLOBAL ENERGY TRANSITION

1 WHERE WE ARE

Batteries are at the center of the EV ecosystem

It's a critical link across vehicles, charging, grid and the circular economy

VEHICLES

- EV affordability
- Range and performance
- Vehicle residual value

CHARGING

- Charging speed and design
- Enables smart charging and load management
- Grid integration

BATTERY

GRID

- Grid flexibility and resilience
- RE integration
- New revenue opportunities (V2G, storage)

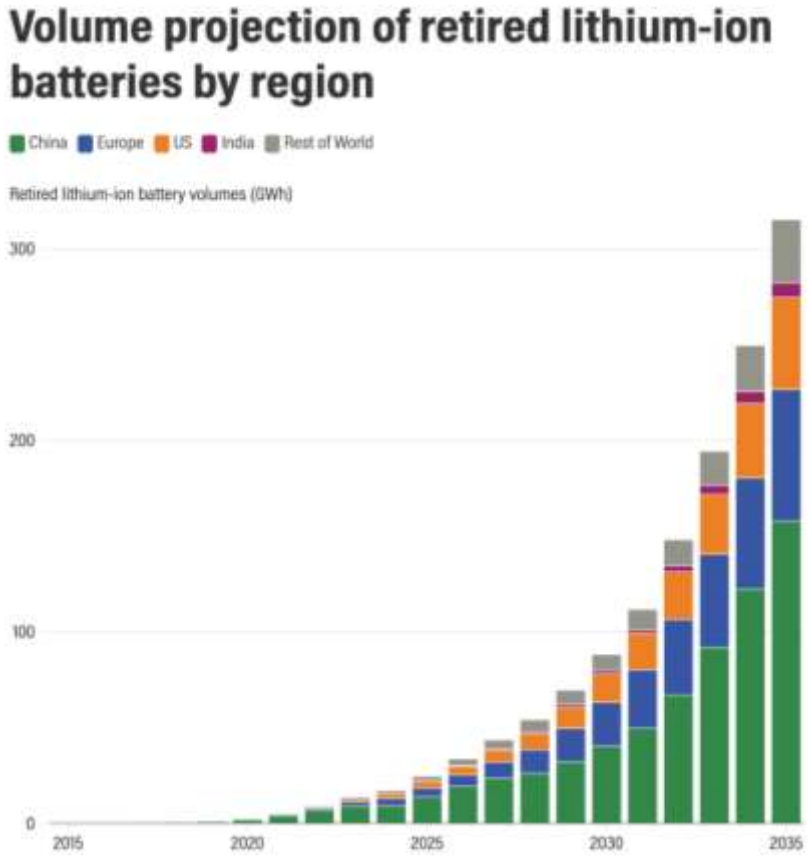
CIRCULAR ECONOMY

- Enables second-life applications
- Recovers critical minerals
- Creates green jobs

The scale is no longer the question

We are moving from an emerging battery industry to a massive industrial ecosystem

- **1.2 TWh,** increase of 30% compared 2024, 7x from 2020.
- Light duty vehicles remained the largest segment, **trucks fastest growing.**
- Stationary storage is seeing a **resurgence** due to data center load and grid demand.
- **EV sales continue to grow** globally.



Source: Link

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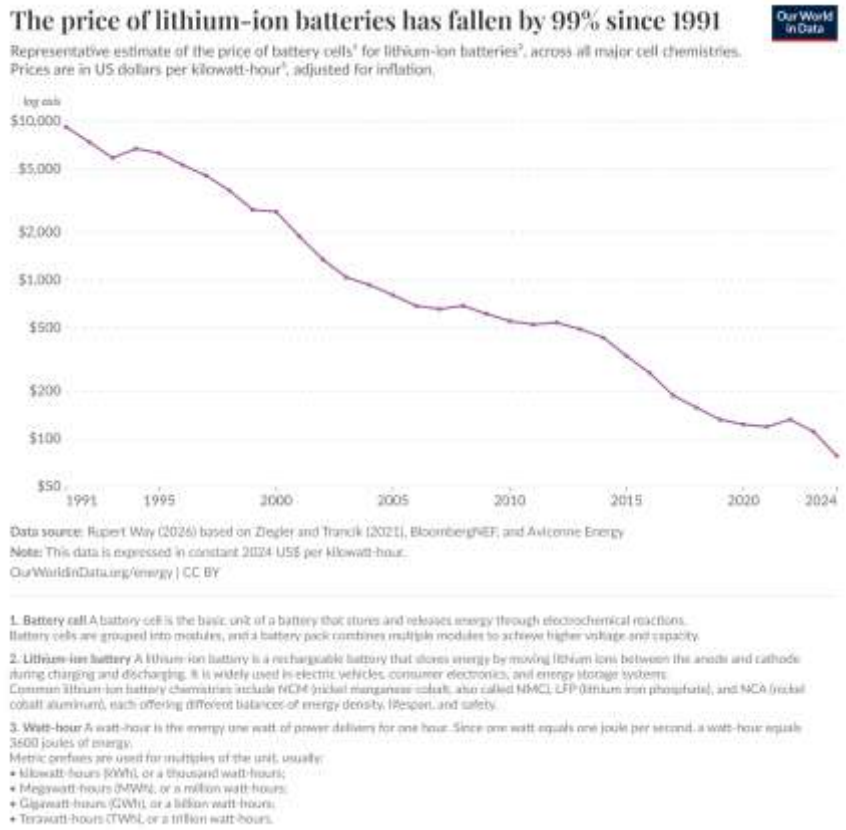
The battery cost curve is rewriting the EV equation

Batteries are getting cheaper, but the benefits are not felt equally

- **Lower cost batteries** lead to
  - More affordable EVs
  - Larger TAMs
  - More batteries entering secondary markets

- **But low prices come with pressure:** Several battery and materials producers are operating on thin margins to compete in the market.

- **China has a structural advantage:** Scale, supply-chain integration and LFP leadership



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Chemistry is changing

The battery of tomorrow may not look like the battery of yesterday

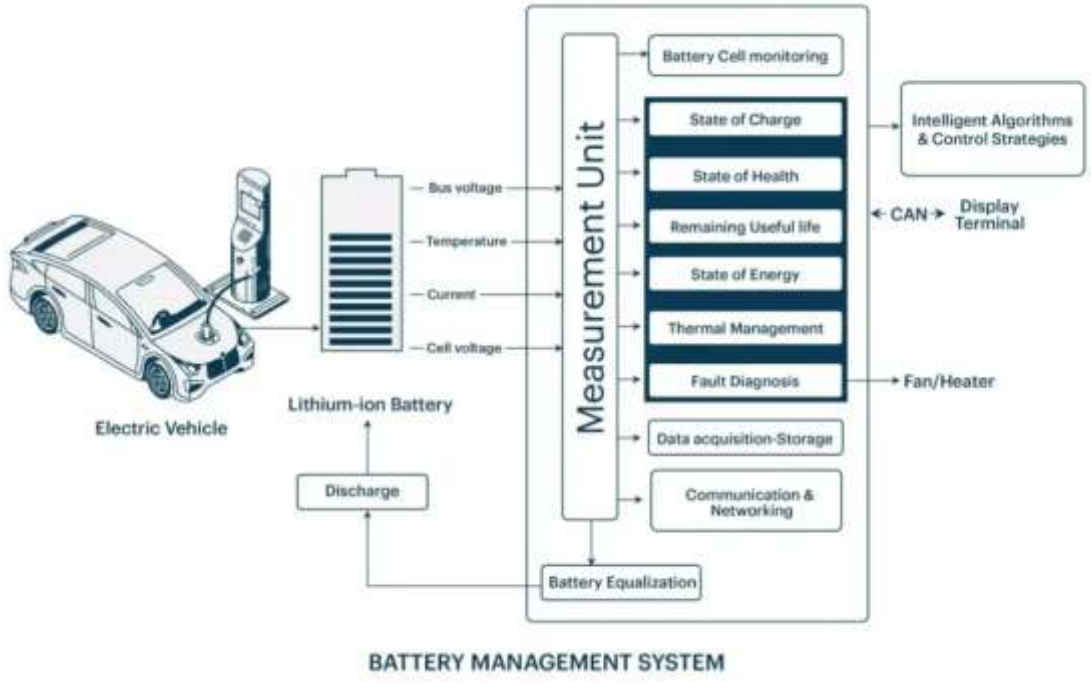
Chemistry	What it brings	Likely role
LFP	Lower cost, long life, no nickel/cobalt	Mass-market EVs + storage
NMC / nickel-based	Higher energy density	Long range / demanding applications
Sodium-ion	Less dependence on lithium	Selected EV + storage applications

LFP retains a major share of the global EV battery market and has a significant cost advantage over NMC

Battery is a data system

The battery is becoming a software + data asset

- A **battery management system** continuously tracks how the battery is performing, charging and aging.
- **Battery health creates value**: Battery data can inform future pathways for battery: use, repurpose, recycle
- The **opportunity is standardization**: Consistent battery-health data, diagnostics and certification could turn an opaque used battery into a financeable asset.



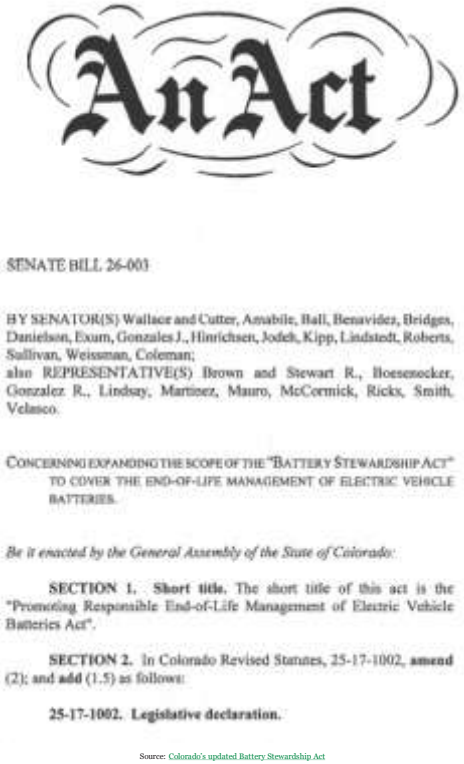
Source: CaviWireless

The value of a used battery depends heavily on what we *reliably* know about it

Battery policy is complex and fragmented

Impacted by policy and regulation across energy storage, critical minerals and transportation

- IRA/IIJA unlocked over $90 billion in U.S. battery manufacturing investments.
- Currently federal policy primarily using a **national security lens** – continues R&D support while falling short on enabling necessary market infrastructure.
- **Growing state policy interest** in battery end-of-life policies like EPR, but too many variations makes it challenging to comply.
- Regulations to meet energy storage goals can be **performance-based.**



An Act

SENATE BILL 26-003

BY SENATOR(S) Wallace and Cutter, Amabile, Ball, Benavidez, Bridges, Danielson, Exum, Gonzales J., Hinrichsen, Jodeh, Kipp, Lindstedt, Roberts, Sullivan, Weissman, Coleman;
also REPRESENTATIVE(S) Brown and Stewart R., Boesenecker, Gonzalez R., Lindsay, Martinez, Mauro, McCormick, Ricks, Smith, Velasco.

CONCERNING EXPANDING THE SCOPE OF THE "BATTERY STEWARDSHIP ACT" TO COVER THE END-OF-LIFE MANAGEMENT OF ELECTRIC VEHICLE BATTERIES.

Be it enacted by the General Assembly of the State of Colorado:

SECTION 1. Short title. The short title of this act is the "Promoting Responsible End-of-Life Management of Electric Vehicle Batteries Act".

SECTION 2. In Colorado Revised Statutes, 25-17-1002, **amend** (2); **and add** (1.5) as follows:

25-17-1002. Legislative declaration.

Source: Colorado's updated Battery Stewardship Act

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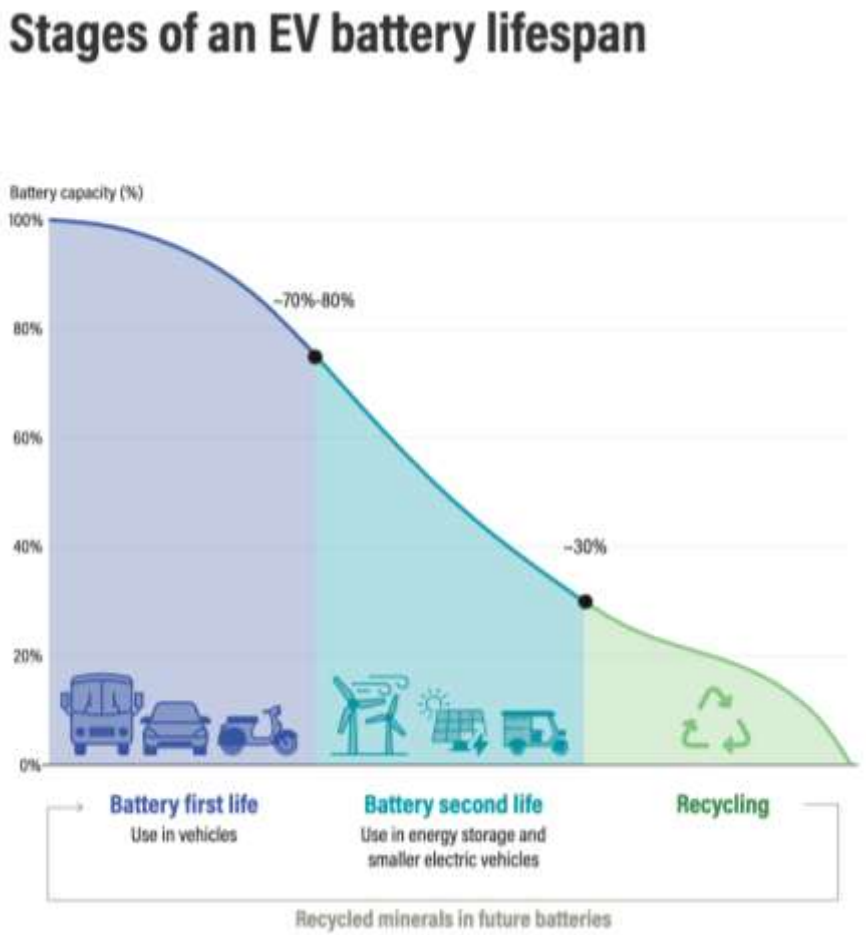
WHAT HAPPENS AFTER IN-VEHICLE USE?

A battery's first-life isn't necessarily its last

The end of automotive life is not the end of battery life



Where can second-life batteries go?

Four markets are particularly interesting

B2U Storage Solutions uses second-life Honda electric vehicle batteries to store solar-generated electricity at a facility interconnected with the local electric utility's distribution system. Photo by B2U Storage Solutions.

GRID STORAGE

- Grid services
- Solar + storage
- Peak management

Solar mini-grid developed by Ceesolar and funded by All On in Oweikorogha Community, Bayelsa State, Nigeria on 4 October 2024. Photo: All On.

ELECTRICITY ACCESS

- Rural communities or remote areas
- Mini grids offer resilience
- Affordable solution

BACK UP POWER

- Data centers
- Telecom
- Community resilience
- Critical infrastructure

Redwood Energy's 63 MWh microgrid combines 12 MW of solar with second-life EV battery storage to power multiple megawatts of modular data centers operated by Crusoe

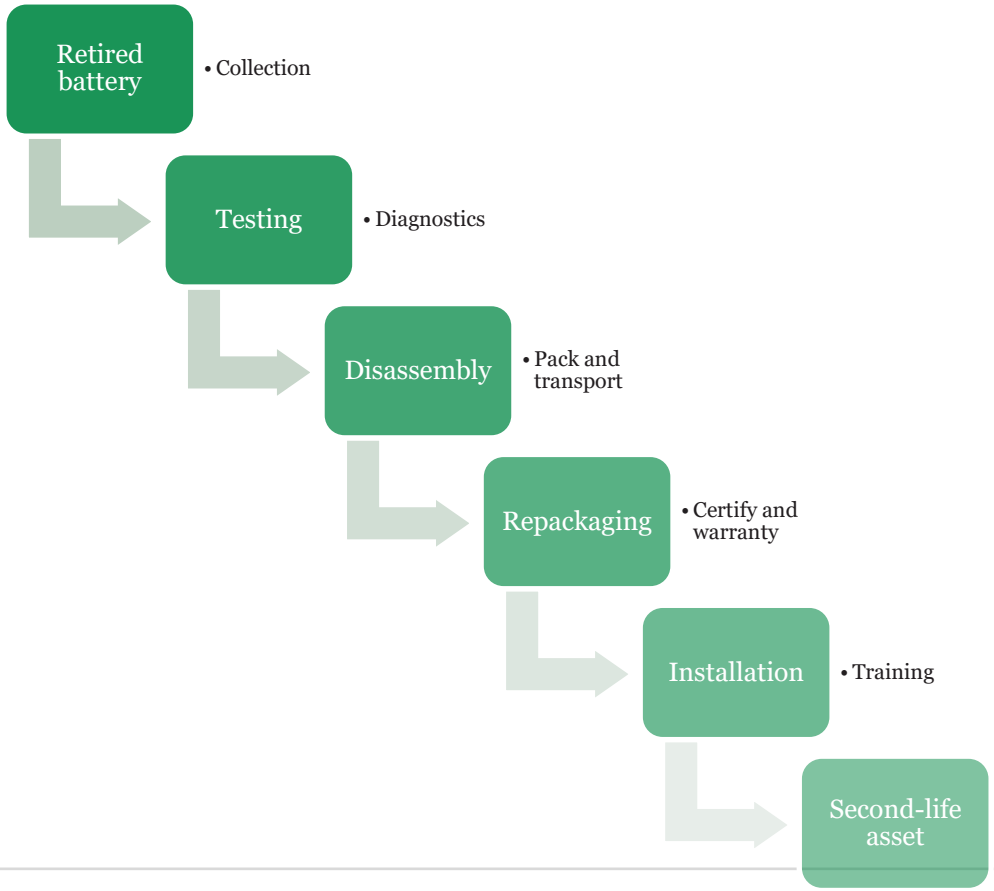
EV INFRASTRUCTURE

- Buffer fast charging
- Reduce fleet TCO
- Avoid grid upgrades and demand charges
- Electrify lower range vehicles

Electric three-wheel vehicles known as tuk tuks, often used as taxis in countries like Thailand and Kenya, can become more affordable by using second-life batteries. Photo by DimaCool/Shutterstock.

But second-life isn’t automatically economical

Separating perceived risk v/s actual risk is a challenge



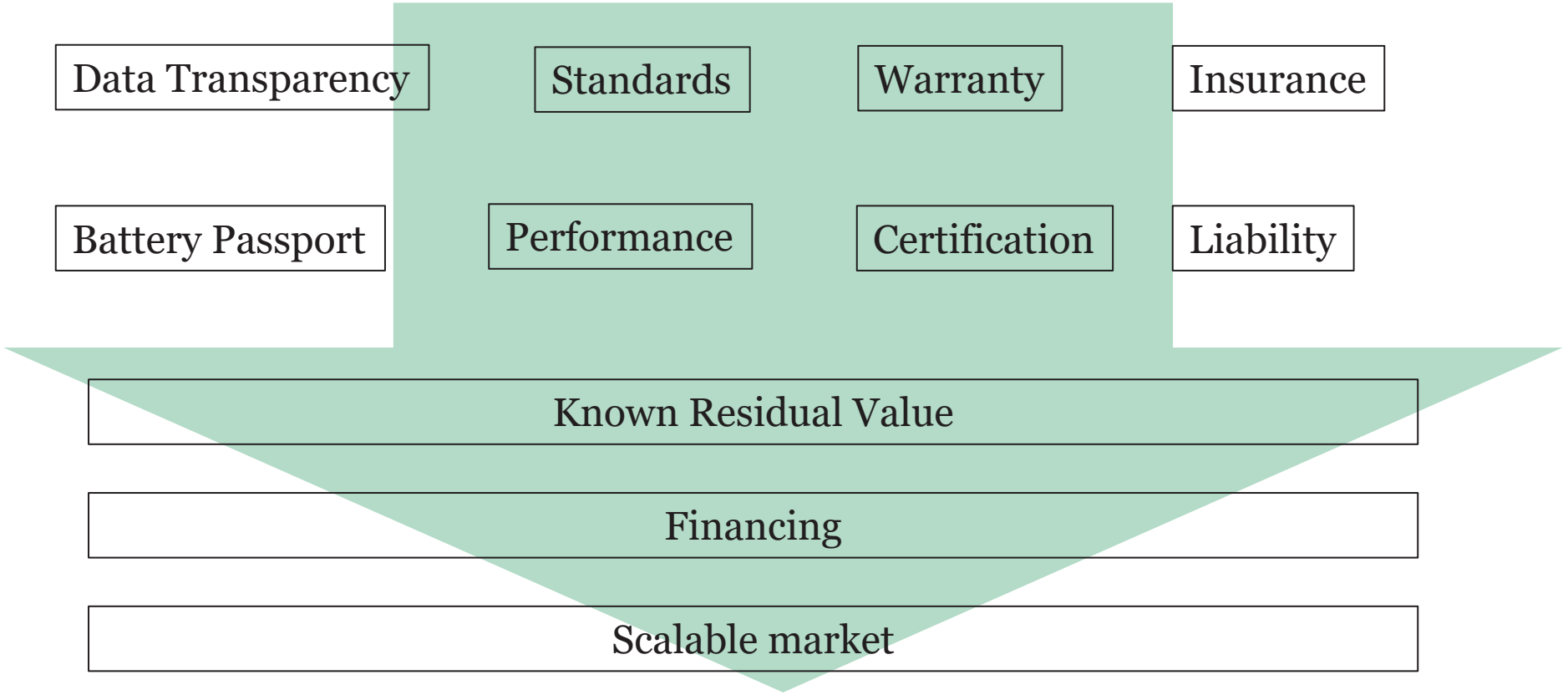
Each step adds:

- Cost
- Safety requirements
- Liability
- Uncertainty
- Time

And simultaneously: falling new battery prices

Opportunity: Make battery health bankable

The missing infrastructure is trust



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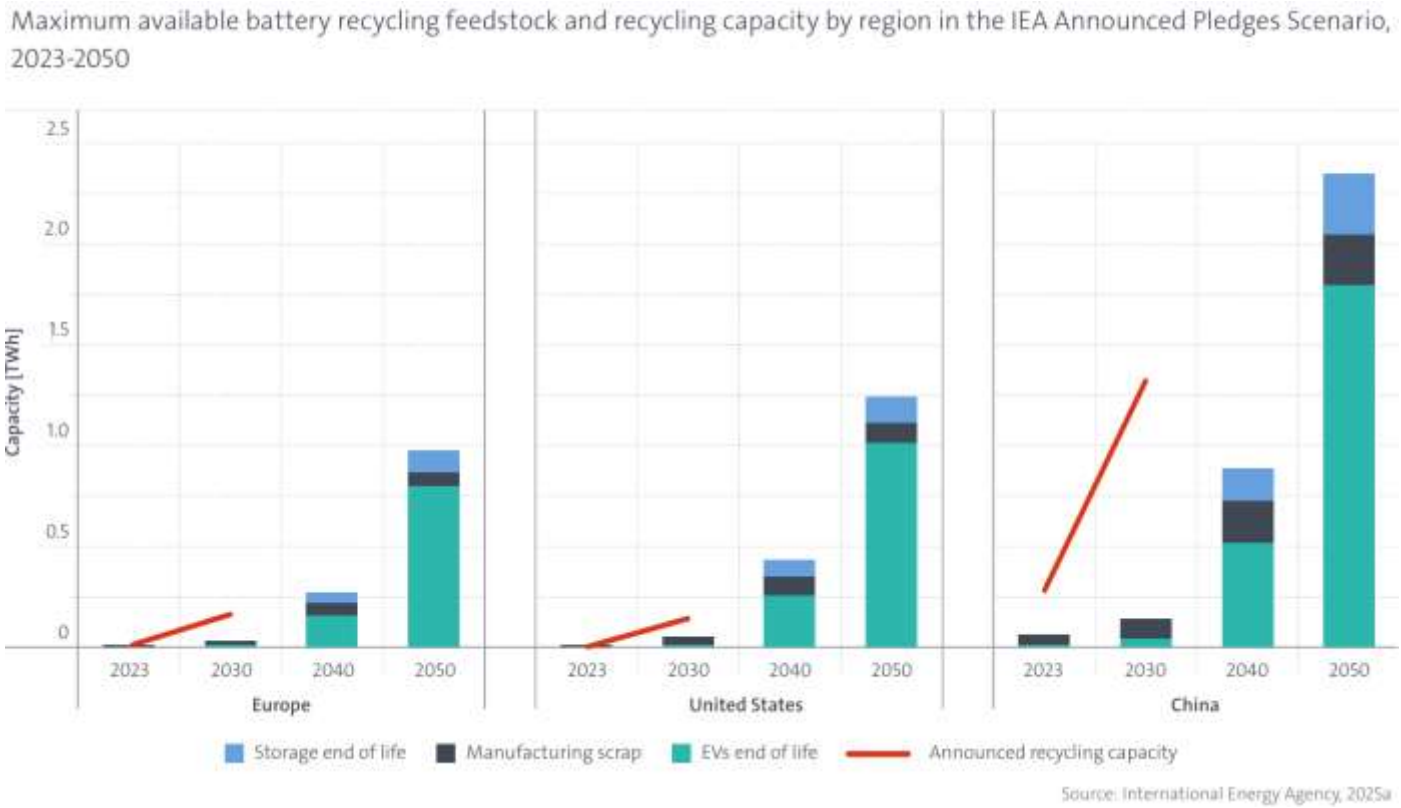
WHAT DOES THE FUTURE HOLD?

The retirement wave is coming

Today's EV sales are tomorrow's battery feedstock

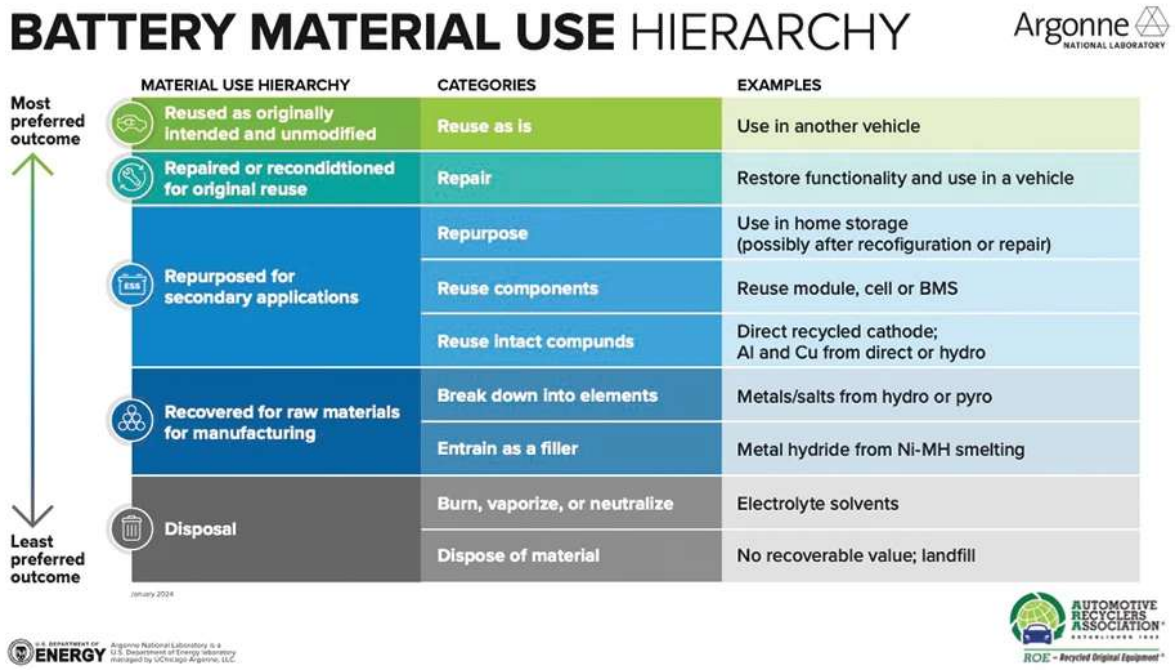


Source: IEA Battery Circularity

The IEA estimates that around **1.2 million EV batteries could reach end-of-life in 2030 and 14 million in 2040**.

Repurposing and recycling aren't competitors

The goal is to maximize value



A battery should go to its highest-value next use and eventually back into the materials system

The next generation of batteries will be designed differently

Can future batteries be designed for its full lifecycle?

Better chemistry
LFP / LMFP
Sodium-ion
Solid-state

Smarter operation
Battery analytics
Bidirectional charging
Predictive degradation management

Better architecture
Modular batteries
Improved thermal management

Circular-by-design
Designed for: repair, disassembly, repurpose, recycling
Improved material recovery

The winning battery may be the one that delivers the most value across its entire lifecycle

4

WHY SHOULD YOU CARE ABOUT THIS?

OEMs, fleets, utilities, charging companies, policymakers all influence what happens at EOL

Five implications for EV infrastructure

1. Charging becomes an energy asset
Charging infrastructure + batteries + smart controls become part of the grid.

2. Battery health becomes an economic asset
Diagnostics and residual value become increasingly important.

3. Fleets become future battery suppliers
Commercial fleets, buses and trucks create predictable future streams of used batteries.

4. Second-life storage may need a demand anchor to catalyze its supply chain
Buyers Collaborative could aggregate demand

5. Circularity needs to be designed into today's EV infrastructure
It would take a coordinated, systems approach to maximize value

HOW IS WRI GETTING INVOLVED?

Education and awareness

Links to articles: 1; 2

Policy and industry engagement

Link to webinar

NY Climate Week 2026

Pilot designs

Co-designed with 20+ actors:

1. Fleet owner planning
2. Utility participation
3. Regional aggregation

Links to article

Global policy framework - 2027

Aim to address two foundational questions:

1. Under what conditions should retired EV batteries be directed toward second-life applications rather than immediate recycling?

2. Where should retired EV batteries be deployed for second-life use—within their country of origin or across borders?

3 QUESTIONS

1. How do we make battery health and residual value bankable?

2. What policies are needed to ensure batteries reach their highest-value use?

3. What market infrastructure (standards, rules, models) do we need to start building today?

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