Future of Retired Electric Vehicles Li-ion Battery Packs

Prathit Dave | pbdave@andrew.cmu.edu
Energy Science, Technology and Policy | Carnegie Mellon University

Objective

This study focuses on **quantifying the mass of critical metal** waste generated Electric Vehicles (EV) LIBs at their retirement in the United States (US).

The study also aims to address the challenge of **battery recycling** with increasing influx of retired batteries in the coming years.

Background

- Demand of Lithium-Ion Batteries (LIBs) is predicted to increase globally in upcoming years, mainly because of the **electrification of transportation**.
- LIB market is predicted to develop threefold by 2030, to **116.6 billion by 2030**, from current market value of $41.1 billion in 2021 .[1]
- With higher demand, LIB supply will increase. However, global demand of LIBs are expected to surpass its supply by 2025.[2]
- Locally, LIB production capacity in the US is set to be 224 GWh in 2025 from 59 GWh in 2020.[3]
- However, recycling rate of all the LIBs is very poor with 5%, mainly because of their design constraints.[4]
- Current LIB manufacturing ecosystem:

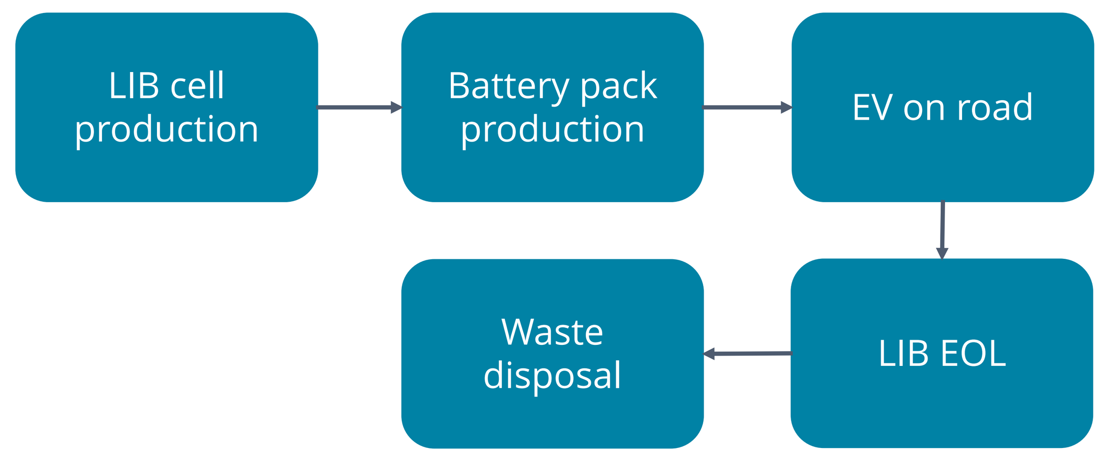

Figure 1: Existing LIB production supply chain

- Steep demand rise in LIBs will generate more waste, with higher value of critical metals in them such as Nickel, Cobalt, Lithium and Manganese.

Quantitative Analysis

Assumptions:

- All the EV LIBs have a lifespan of **10 years**.
- EVs include both kind of passenger vehicles: Plug-In Hybrid Vehicles (PHEVs), and Battery Electric Vehicles (BEVs)
- **Four types of battery chemistries** and sales data of **top 10 EVs models** in the US are taken into consideration to forecast the mass of critical metals.
- Cathode accounts for **30% of total LIB mass** for all chemistries

Methodology:

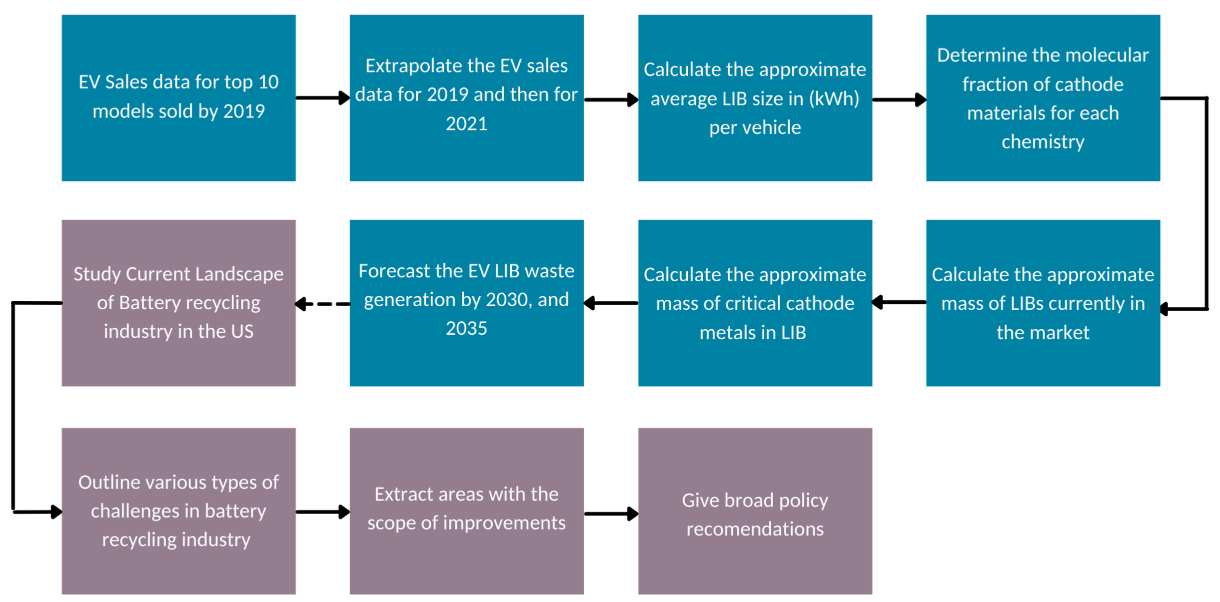

Figure 2: Steps of the research study

Current Market Trends:

- Till 2019, top 10 EV models accounted for **90% of total EV sales** in the US.[5] Also, more than 2.1 million EVs were sold in the US by August 2021.[6]
- **Same proportion** of those models in 2019 is extrapolated to estimate the mass of critical methods used in EVs by 2021, and therefore total waste generation by year 2030.
- Average size of LIBs used in EVs was found to be **57 kWh**. Total waste generated by 2030:

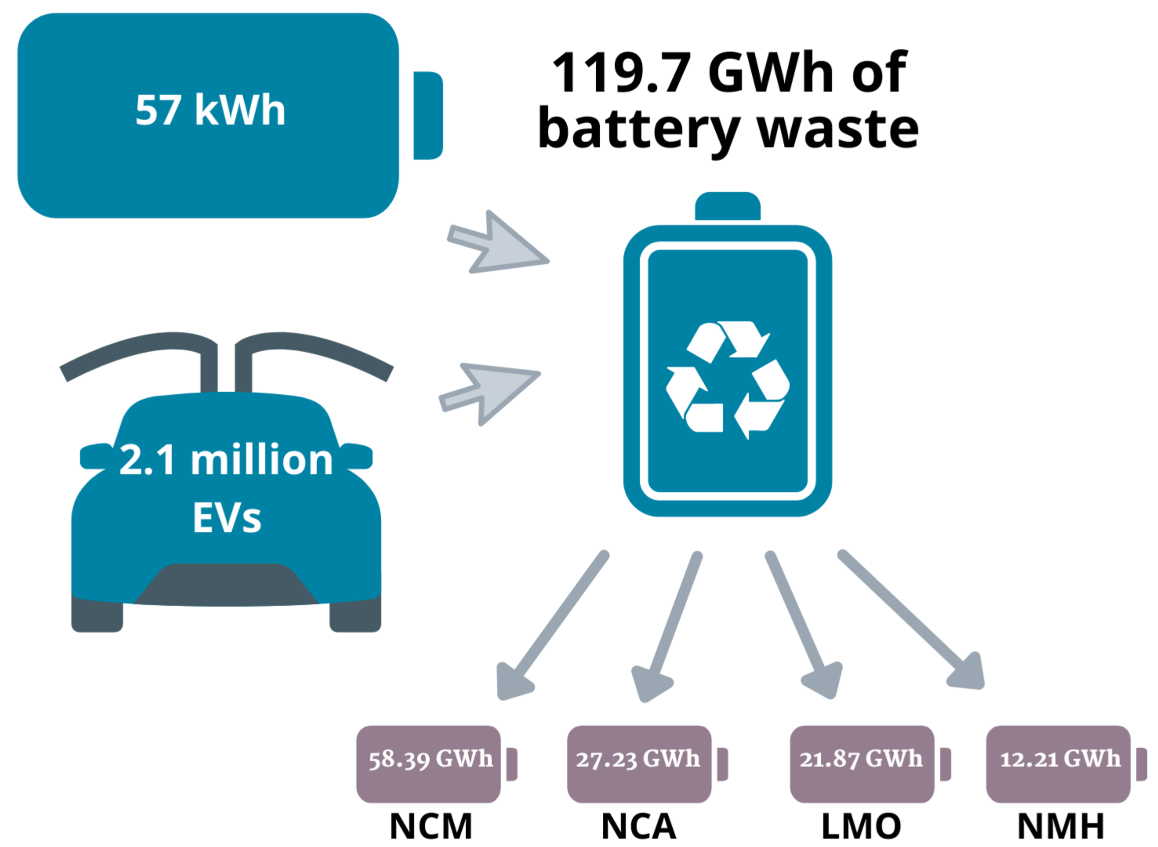

Figure 3: Estimated battery waste generation by 2030

Critical metal masses in each battery chemistries from figure 3:

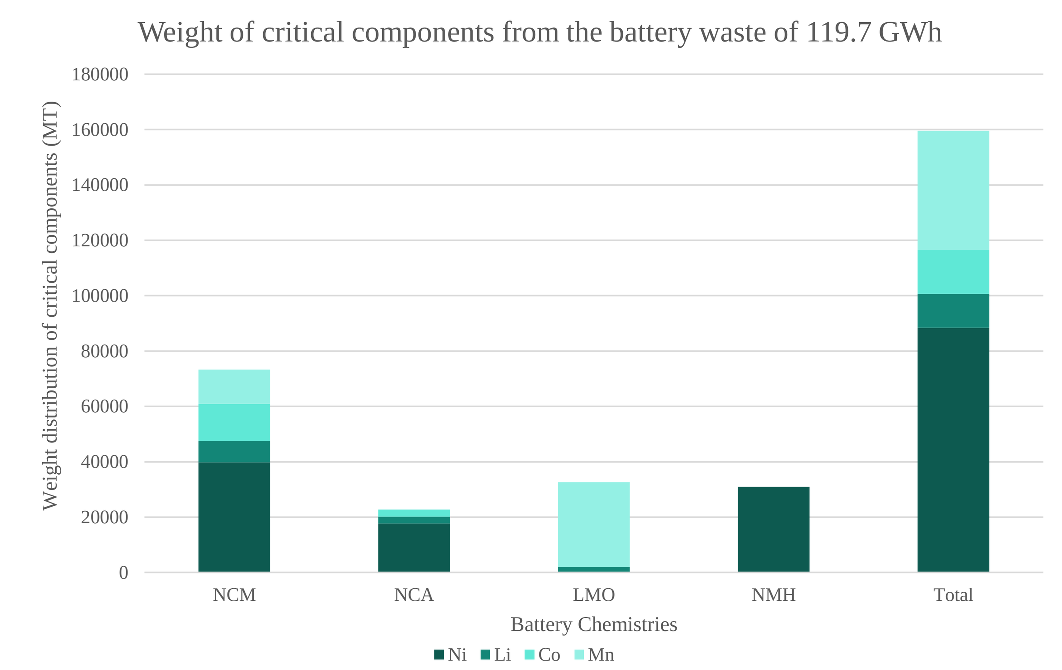

Figure 4: Weight of critical components from the battery waste of 119.7 GWh

Emerging LIB Recycling Startups:

- Many LIB startups are emerging with their technological and innovative supply chain innovations:

Startup	Technology	Battery Recycling Capacity	Location	Salient feature of business model
Li-cycle	Hydrometallurgy	10,000 MT/yr	Canada, US	Hub and spoke supply chain
Redwood	-	677,850 MT/yr (by 2025)	US	Focused on large-scale battery production
Lithion	Hydrometallurgy	10,000 MT/yr	US	Collaboration with logistics organization
Battery Resourcers Inc	Hydro-to-cathode	10,000 MT/yr	US	Produces battery ready cathode materials
Duesenfeld	Mechanical +Hydrometallurgy	3,000 MT/yr	Germany, US	Recycles cathode ready battery materials + logistics network

Figure 5: List of LIB recycling startups and salient features

Scope of Improvement:

- Figure 6 outlines the broad areas with the scope of improvements:

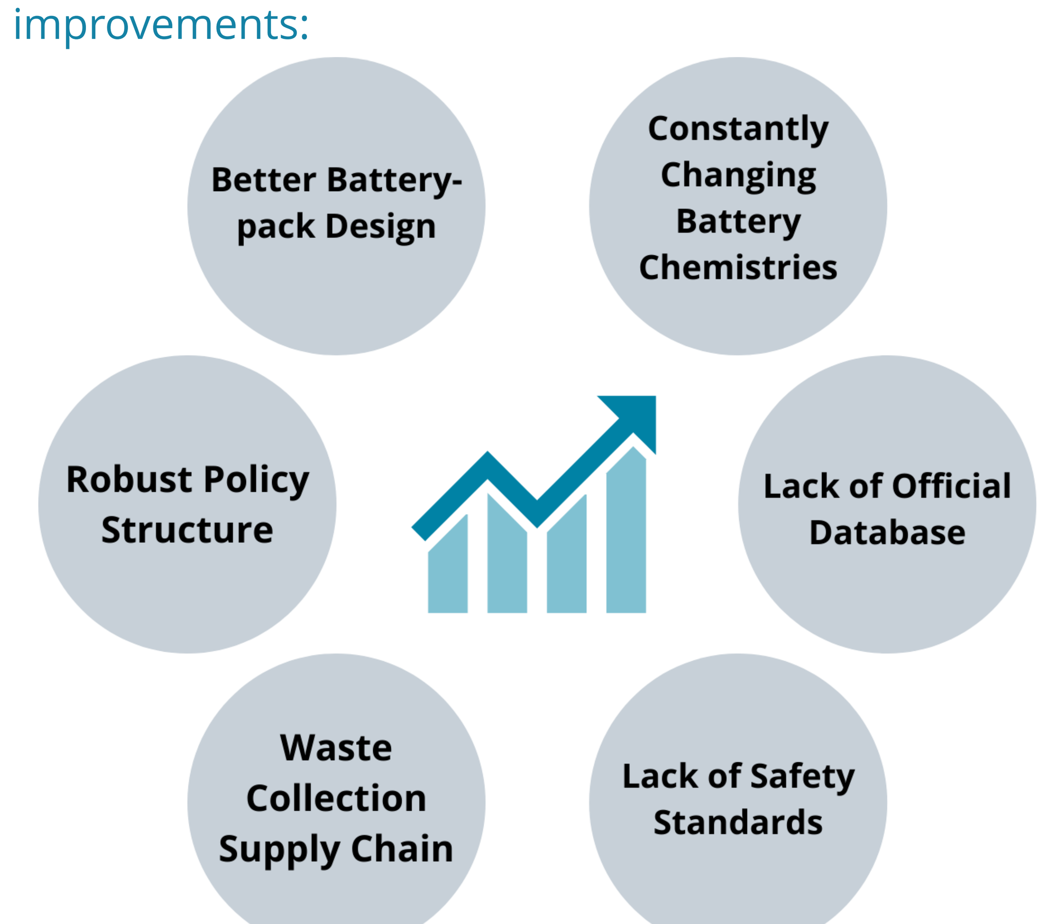

Figure 6: Broad areas of scope of improvement

Recommendations

Broadly, **circularity** in the EV LIB supply chain should be introduced, as per the following figure:

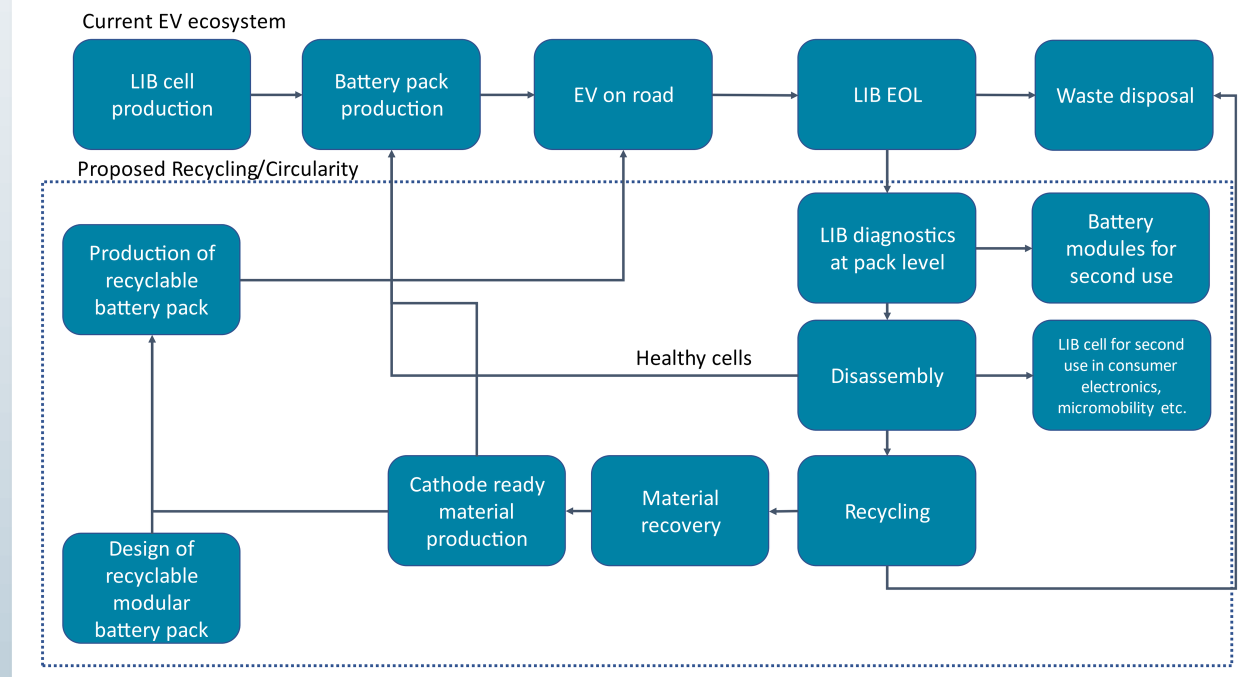

Figure 7: Proposed circular ecosystem of LIB production

To adopt the proposed ecosystem, following policy recommendations should be emphasized:

1. **Research Grants**:
   - LIB diagnostics equipment
   - Modular battery-pack designs
2. **Incentives**:
   - Logistics firms
   - End consumers
   - Security deposits
3. **Regulations:**
   - LIB manufacturers
   - Centralized regulatory reporting system (CRRS)
4. **Education/Awareness:**
   - Awareness about environmental impact about

Acknowledgements and References

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