A Technoeconomic Analysis of Electric Vehicle Battery Repurposing for Stationary Storage Applications

Anna Cobb[1], Katrina Ramirez-Meyers[2], Shashank Vaswinathan[2], Paul Gasper[4], Jeremy Michalek[1,3], Kandler Smith[4]

Carnegie Mellon University, [1]Department of Engineering and Public Policy, [2]Deparment of Materials Science and Engineering, [3]Department of Mechanical Engineering; [4]National Renewable Energy Laboratory

Motivation

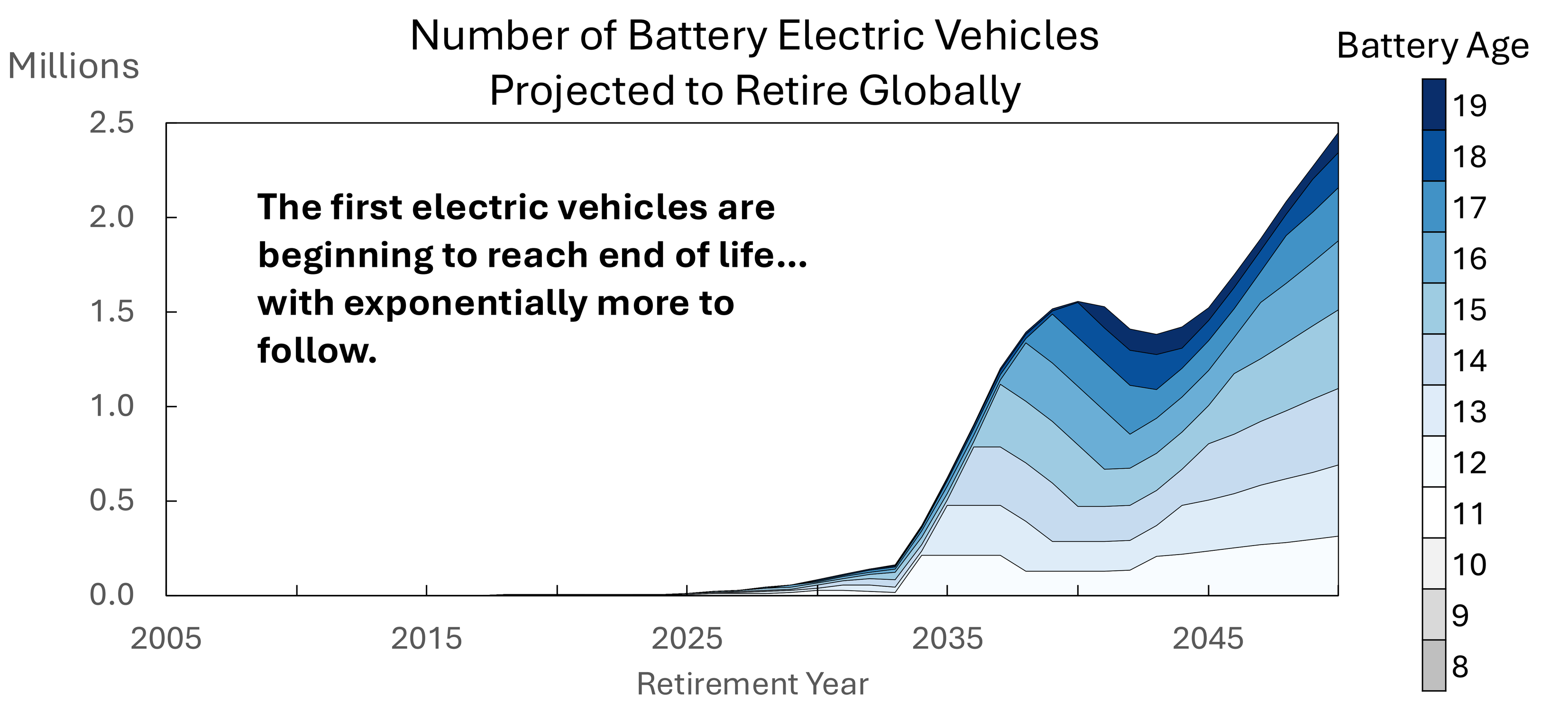

Figure 1. Projected retirement of battery electric vehicles based on modeling by Xu et al. [1]

Methods

Repurposing Cost Model

At-scale annual costs of operating a repurposing facility were estimated with a process-based cost model. Figure 2 shows the process flow modeled, which was developed based on interviews with industry experts, academic literature, and relevant standards—specifically, UL 1974 [2].

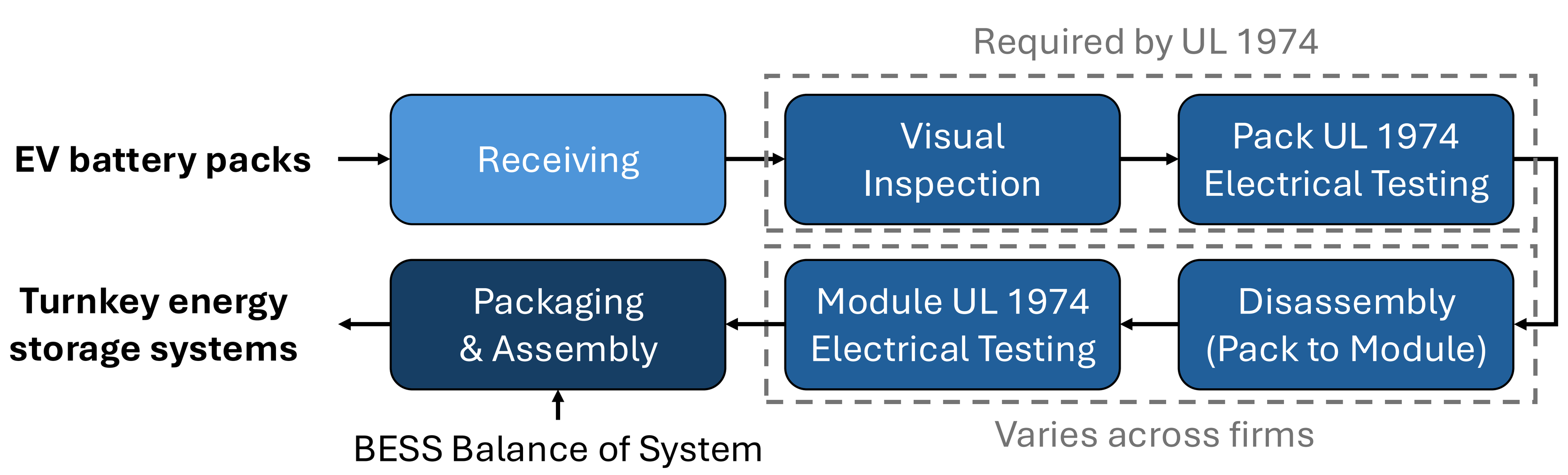

Figure 2. Repurposing process flow modeled in process-based cost model

Battery Degradation & Lifetime Modeling

The BLAST-Lite battery modeling tool [3] was used to simulate the 1st and 2nd lives of 3 EV battery chemistries under various use conditions.

Table 1. Parameter values tested for battery first and second life simulations

Parameter	Values Tested
Application	C&I* Peak Shaving, C&I* Load Shifting, EV Charge Support
Annual VMT during 1st Life	7.8k, 14k, 18k [miles]
Length of 1st Life	12, 15, 18 [years]
Battery Cathode Chemistry	NMC622, NCA, LFP
Derating Factor	1.05, 1.11, 1.25, 1.43, 1.67, 2.0, 2.50, 3.33, 5.0

*refers to Commercial and Industrial

Breakeven EV Pack Price Calculation

The maximum amount a repurposer would be willing to pay for a used EV battery is calculated by setting annualized costs of a new battery energy storage system (BESS) equal to annualized costs of a second life BESS (SLBESS).

$$Annualized\ cost = system\ cost \times capital\ recovery\ factor$$
$$= f(c_{batt}, c_{BOS}, c_{rep}) \times g(lifetime, discount\ rate)$$

where c_{batt} is battery cost, c_{BOS} is balance of system (BOS) cost, c_{rep} is repurposing cost

Results

How much does it cost to repurpose an EV battery?

Excluding assembly, module- and pack-level costs are \$32/kWh and \$13/kWh, respectively. Including assembly, module- and pack-level costs increase to \$174/kWh and \$141/kWh, respectively.

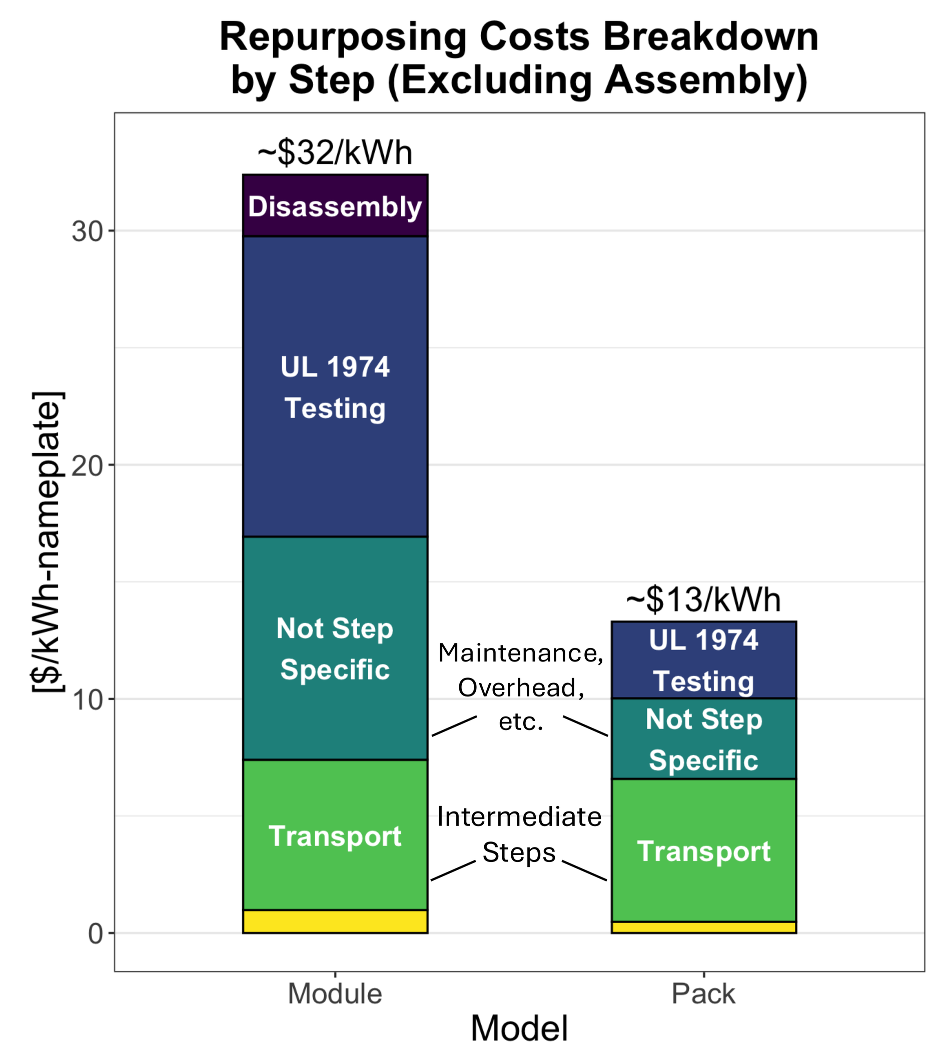

Figure 3. Repurposing cost results broken down by (grouped) process steps for module-level and pack-level repurposing.

How long will an EV battery last in its second life?

EV batteries may last up to 16 years depending on their 1st and 2nd life use intensities, as well as their chemistry and derating factor.

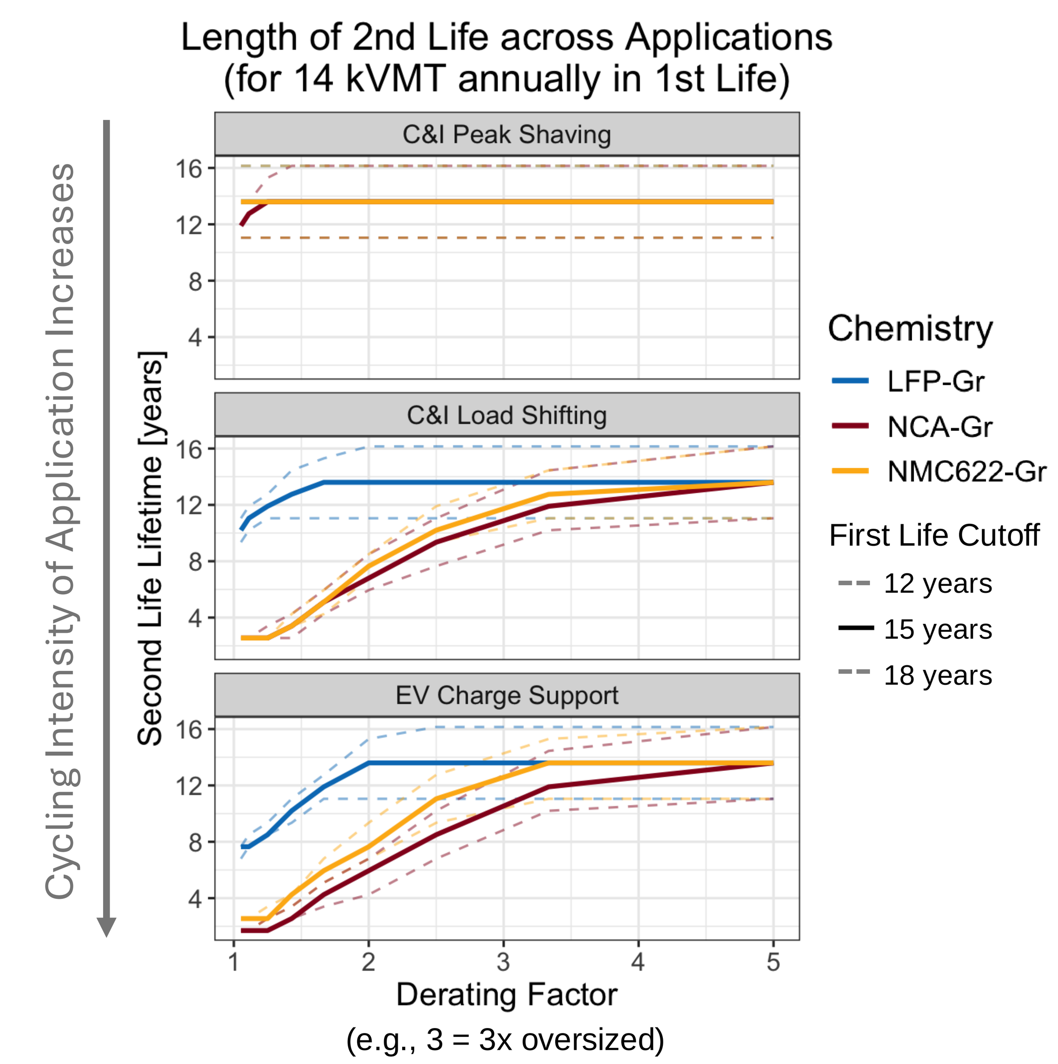

Figure 4. BLAST-Lite modeling results for length of EV battery 2nd life across applications. Applications increase in their intensity from top to bottom.

How much is a used EV battery worth to a repurposer?

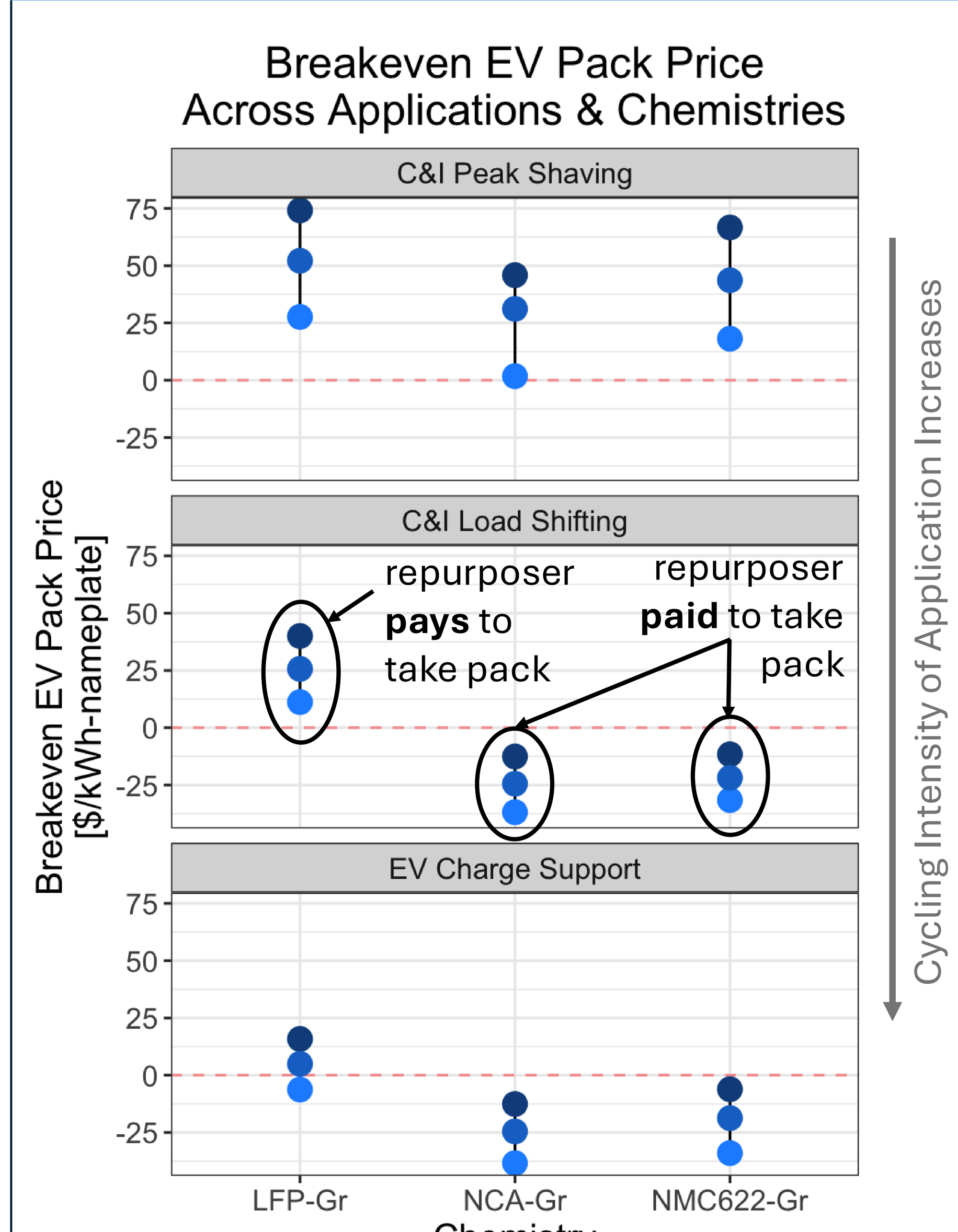

Figure 5. Breakeven EV pack prices across chemistries and first and second life scenarios.

In **low intensity** applications...

All pack chemistries have the potential to be valuable to a repurposer. However, chemistry and 1st life conditions still heavily influence the exact amount.

In **high intensity** applications...

LFP is still valuable to repurposers, but nickel-based chemistries can't last long enough to be useful.

Compared to recycling...

Table 2. Recycler and repurposers willingness to pay for used EV packs (in \$/kWh-nameplate)

Battery Chemistry	Recycling* (Direct)	Repurposing
LFP	(\$8.16)	(\$6.26) – \$74.10
NCA	\$10.40	(\$48.40) - \$45.90
NMC622	\$9.90	(\$34.00) – \$66.70

*Recycling values were obtained using EverBatt, a battery recycling cost and environmental impacts model developed by researchers at Argonne National Lab [4].

Conclusions

1. Repurposing is much more expensive at the module- than pack-level due to UL 1974 testing requirements.
   - Research in rapid diagnostic testing could help lessen this difference.
2. 2nd life BESSs have the potential to last up to 16 years (the same life as some new BESSs).
3. Repurposing can be a more economically viable option than recycling for LFP packs.
4. For nickel-based battery chemistries, 1st life conditions and 2nd life application heavily influence economic viability of repurposing.

References

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