Battery Disassembly in Support of Material Reuse

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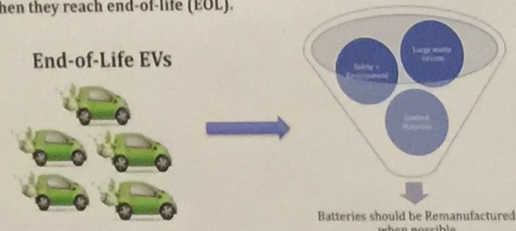
Background – Batteries from Electric Vehicles (EVs)

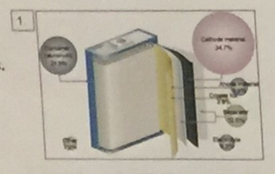
Over 4,000,000 hybrid EVs and 400,000 plug-in EVs have been sold in the U.S[1]. The batteries from these cars represent a unique material challenge when they reach end-of-life (EOL).

End-of-Life EVs



Batteries should be Remanufactured when possible

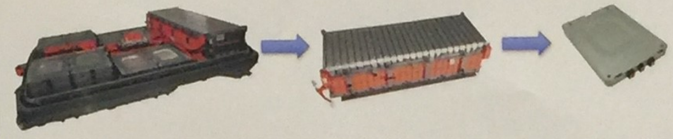
1. Recycling is challenging because there are so many materials in these batteries. There are also few high-value materials to be recovered.
2. Landfilling wastes valuable battery materials and potential leaching concerns.
3. When possible, remanufacturing (reuse) of batteries avoids many of these problems



1. http://www.afdc.energy.gov/data/widgets/10567

Approach – Battery Disassembly

- Disassemble batteries to see what areas are challenges to disassembly to the module level
- Time disassembly for different battery brands and compare
- Compare brands, make recommendations for faster disassembly



Battery Disassembly Steps

1. Remove cover
2. Disconnect major busbars, then minor busbars
3. Disconnect power cables, then remove
4. Disconnect relay box
5. Disconnect BMS
6. Disconnect and remove cooling system
7. Remove sections
8. Remove any internal busbars and remove modules.

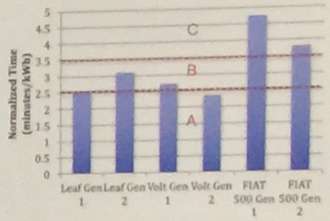
Required Tools

Multimeter | Insulated gloves | Torque Driver

Pry bar | Industrial vacuum | Hydraulic crane

Assessment

Normalized Disassembly Time



Normalized Disassembly Time (min/kWh)	Score
<2.5	A
2.5-3.5	B
>3.5	C

In order to "score" batteries, we first needed to normalize each type by their energy. This is the best way to compare battery to battery. (Larger batteries clearly take more time to disassemble.) Then we created a scorecard to group batteries into three categories of disassembly difficulty

Conclusions and Suggested Work

- There is a huge variance in disassembly time from brand to brand.
- Removing glue on the battery cover is the best way to reduce disassembly time and reduce distortion which prevents remanufacturing.
- Minimizing fastener use, using a standardized bolt fastener, and replacing irreversible fasteners with snap-fit fasteners will enable remanufacturing
- Future work in the area of reversible glues would be advantageous.
- Similarly, research of fasteners for rapid disassembly would be beneficial.

Examples of reversible fastener designs for disassembly

The Problem – Barriers to Remanufacturing

General Remanufacturing Steps:

- Transport to remanufacturing facility
- Battery charging and discharging tests
- Disassembly to module level
- Module grading (by capacity)

- There are many brands and designs of batteries meaning disassembly is different for each brand
- Disassembly can take a long time (not designed to be disassembled) = high labor costs
- Complicated combination of hundreds of parts

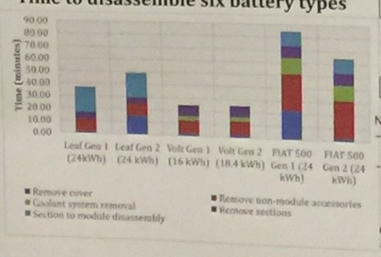
Designing for disassembly should be a large focus

Questions to answer:

1. How long does it take to disassemble different batteries brands?
2. What fasteners are currently used and what fasteners are possible?
3. What other aspects of design should be changed to enable disassembly?

Results

Time to disassemble six battery types



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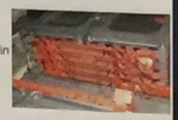
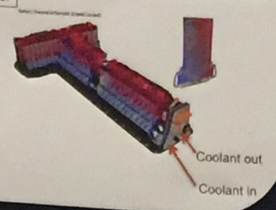


Nissan Leaf
- 98 fasteners to retain sections
- 146 fasteners to retain modules

Chevy Volt
- 28 bolts to retain sections

3.



Key Results

1. Glued batteries take 20 extra minutes to disassemble
2. Number and type of fasteners can vary widely, impacting disassembly
3. Liquid cooling adds disassembly time but spares battery health

Acknowledgments

This work has been funded by the Center for Resource Recovery and Recycling (CR3) and the National Science Foundation (NSF). In addition, the disassembly was performed with the help of Spiers New Technologies (SNT), to whom we are very appreciative.

Many thanks to my advisors, Dr. Yan Wang and Dr. Diran Apelian for their help and advice. In addition I owe thanks to the leaders of my focus group, Christopher Taylor and Mark Bauer.