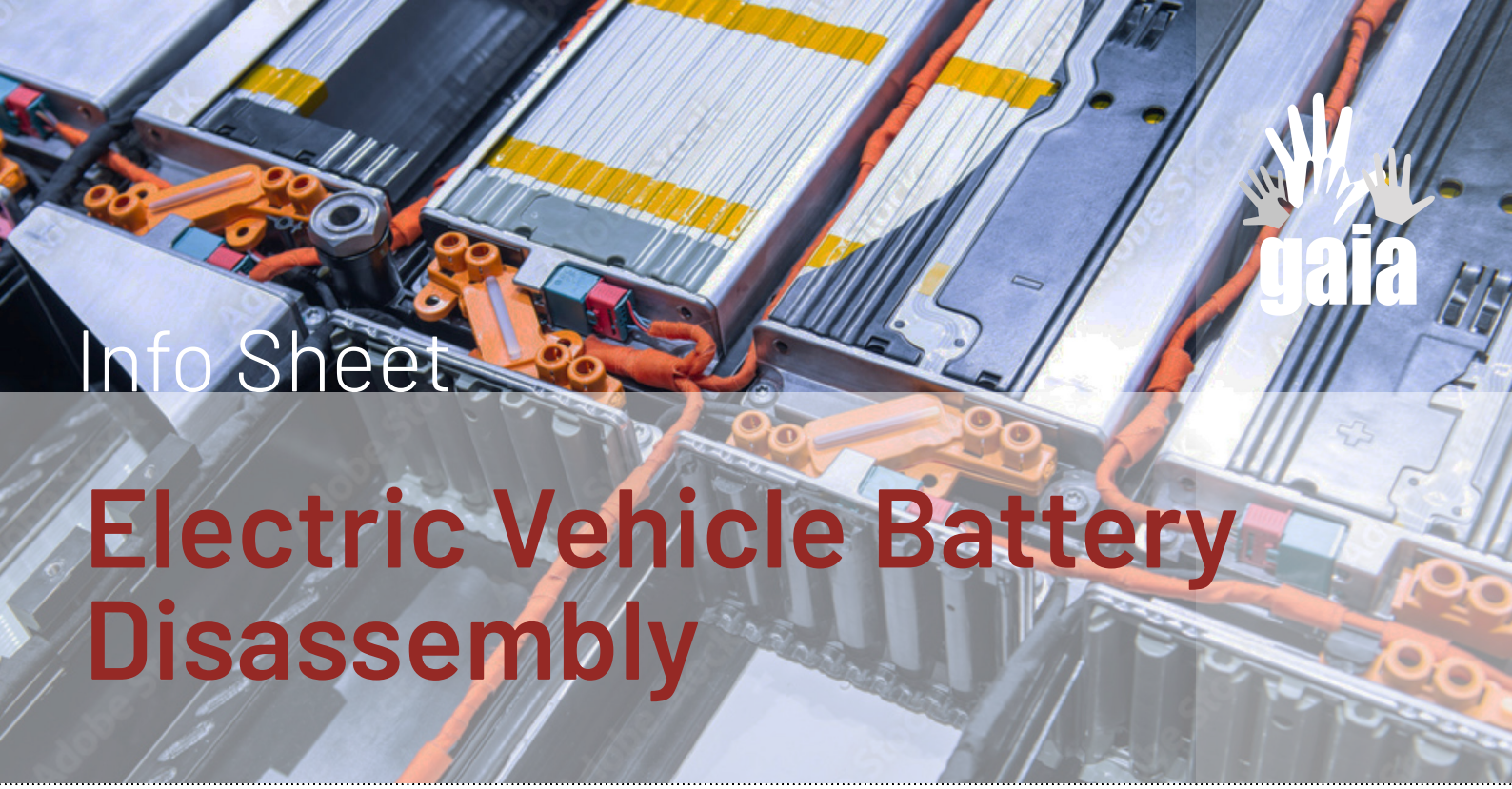

Info Sheet

Electric Vehicle Battery Disassembly

What is disassembly?

The objective of electric vehicle (EV) battery disassembly is to take the EV battery casing and modules apart in order to repair, refurbish, reuse, repurpose or recover materials for recycling. Designing a battery for ease of disassembly and reassembly is an important element that can extend the battery life by enhancing prospects for reuse, repair, repurposing, and recycling.

Understanding the hierarchical relationship between the cell, module, and battery pack is crucial for comprehending the disassembly processes of EV batteries. The battery cell is the basic unit of the battery, responsible for generating electrical power through chemical reactions. Depending on the manufacturer, a total of 12 to hundreds of these cells are combined to form a module and are typically wired in series. This layout allows the cells to work together, effectively increasing the voltage and energy capacity to meet specific battery pack requirements. These modules are then arranged and interconnected to form the battery pack and then lastly are installed in an electric vehicle as one unit.

Please see diagrams of battery components and other relevant details in the following info sheet: Understanding Basics of Electric Vehicle Batteries (GAIA, 2024), available on: www.no-burn.org/batteries

Challenges with disassembly

Constructed for safe operation, not disassembly

Battery packs in EVs are engineered to withstand a broad spectrum of severe conditions, including extreme temperatures, impacts from collisions, and environmental challenges such as exposure to moisture and dust. Moreover, they are constructed to resist damage from puncturing or excessive pressure, which could cause electrolyte leakage and precipitate thermal runaway. This scenario is particularly hazardous during the disassembly process to the cell level, where technicians may need to pry apart adhesives or polymers holding the battery cells together, **increasing the risk of injury and triggering thermal runaway** (a phenomenon in which the lithium-ion cell enters an uncontrollable, self-heating state). Such a reaction can lead to the overheating of adjacent cells and potentially cause combustion, resulting in significant damage and posing a serious safety risk if technicians lack the proper protective equipment such as high-voltage gloves, a voltmeter, and proper extinguishers.

To counter these dangers, manufacturers protect these packs with durable metal casings and layers of protection. While it is critical to prioritize safety through these design choices, it is equally important to consider the ease of disassembly. Ensuring battery packs are easily disassembled not only improves the safety of technicians working with these systems but also supports sustainable practices by facilitating the recycling and recovery of valuable materials and components.

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Complex, destructive process requiring proprietary tools

The process of disassembly for popular EV battery packs might begin with **the removal of complex interior components** such as the front and rear seats, carpet, and any fixtures blocking access to bolts connected to the frame of the vehicle. In the disassembly of Tesla's Model 3, the first EV to reach 1 million sales globally,[1] some have said that complete interior removal was required to remove only 15 bolts.[2] Such a complex process requires pry tools, a standard socket set, and a 5-star socket unique to the manufacturer.[3] Once the upper bolts are removed, the bottom of the vehicle needs to be disassembled.

Further disassembly processes are dependent on the manufacturer but typically involve disconnecting any connections to the motor, draining the cell coolant, and unbolting certain protective plastic and external covers. After all connections have been properly removed, recyclers and repair shops need specialized pallet jacks to support the weight of the ~1,000 lb battery pack. Once the pack is separated from the vehicle, technicians and recyclers can access the bolts that hold the battery pack's protective cover together.

With the battery pack separate from the vehicle, **removing the casing** is the next step. These covers sometimes consist of a metal composite that tightly shrouds the batteries, creating a flame-retardant barrier. The covers are also sealed with strong epoxy which makes removal of the casing (for the purpose of repair) destructive and dangerous, as technicians need to pry and risk puncturing sensitive lithium-ion cells to get access to modules.

Once the cover is removed, technicians finally have access to battery modules. At this point, technicians are working with exposed battery contacts on the module. The disassembly process will now **require the battery module to be discharged** by being connected to a resistive load (circuit with resistance) to discharge the battery. Despite this key precaution, faulty battery modules might not properly discharge or output the correct information and therefore require careful disassembly and constant voltage measurements. Once an individual module is removed, technicians who are seeking to recycle or repair the individual cells can now begin the process of extraction by maneuvering and chiseling the polyurethane foam and adhesives found between each of the hundreds to thousands of cells.

These are the disassembly issues specific to EV batteries with cell-to-module construction. Cell-to-pack and cell-to-chassis design is more difficult to disassemble, and therefore would result in even lower recyclability.

1 Shahan, Zachary. "Tesla Model 3 Has Passed 1 Million Sales. CleanTechnica. https://cleantechnica.com/2021/08/26/tesla-model-3-has-passed-1-million-sales.

2 (Byron) Youtube, "Tesla Model 3 Battery Pack Removal Guide." https://www.youtube.com/watch?v=T-MxNpVxlqc.

3 (Stele Auto Group) Youtube, "Tesla Model 3 Battery Removal." https://www.youtube.com/watch?v=DPVrraVbEIM.

Recommendations for safe and efficient EV battery disassembly

Optimizing for Efficiency and Safety

The need for a more safe and streamlined process for disassembly methods has become increasingly clear. Some manufacturers have already streamlined part of the process. For example, in a Chevy Bolt, the process of removing and reinstalling a new battery pack is said to take about 4.5 hours to perform by trained GM dealership technicians, while most battery swaps take up to 15 hours.[4] In order to make the process more efficient, a possible design route could be to permit technicians and recyclers access to each module from the underside of the vehicle without the need for battery pack removal and cost-intensive design features.

Through a simpler linear design (components bulked together)[5] and standardized screws, the disassembly process can be safer.[6]

Battery Pack Swapping

The current model for electric vehicle batteries prioritizes a rapid and cost-efficient assembly at the expense of disassembly. This approach caters to the increasing demand for EVs and allows manufacturers to scale up production swiftly. This current design choice makes battery pack swaps a complex and labor-intensive process. However, this landscape is already changing. For example, Nio, a Chinese EV company, has developed "Power Swap" stations that will autonomously swap a drained battery pack for a fully charged one in only three minutes.[7] This modular design addresses disassembly concerns.

4 Find My Electric on "Chevy Bolt Battery Replacement Cost." https://www.findmyelectric.com/blog/chevy-bolt-battery-replacement-cost; "Electric Car Battery Replacement Cost Explained." 2023. Find My Electric (blog). March 25, 2023. https://www.findmyelectric.com/blog/electric-car-battery-replacement-cost.

5 Outlook of EV battery pack design trends: Assessment of trend impact from a recycling perspective. https://kth.diva-portal.org/smash/get/diva2:1786790/FULLTEXT01.pdf.

6 Ibid.

7 Nio on Nio Power Swap: "Fully-automatic battery swap in just a short coffee break."

Recommendations for safe and efficient EV battery disassembly

Challenges		Solutions
Battery packs are built with robust metal casings and protective layers for safety and durability	**Access to the battery pack**	Streamlining the battery pack disassembly process (through a simpler power disconnect, a slot mechanism, standardized parts)
Battery isolation is constrained and the entire battery pack is discarded when there's a single faulty module	**Access to the battery module**	Enabling battery pack swaps (modular approach) for replacement
Workers and technicians exposed to risks of explosions, fires, and contacts with toxic substances	**Occupational safety**	Reducing the usage of toxic substances through redesign & providing training, certification, manuals for safety
Technical manuals and proprietary tools are not accessible to third-parties	**Access to technical manuals & proprietary tools**	Provide access to information for safe disassembly, including manuals and proprietary tools
The high cost and complexity of battery replacement can exceed the value of the vehicle	**Lifecycle and sustainability**	Establishing industry standards for battery refurbishment and second-life applications to encourage sustainability beyond the vehicle's life
Destructive disassembly methods can pose safety risks and reduce recyclability	**Module and cell level disassembly complexity**	Encouraging manufacturers to design for end-of-life recovery and take into account technician safety

Acknowledgements

- Author(s): Omar Osvaldo Reyes and Sheila Davis
- Editor(s): Lien De Brouckere, Erica Jung, and Doun Moon
- Design: Doun Moon
- Reviewer(s): Claire Arkin and Kenza Sara Elazkem

See GAIA's Battery Info Sheet Series at: www.no-burn.org/batteries.