

Repurposing EV Batteries for Second-Life Stationary Storage: Market Landscape and Key Challenges

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This brief discusses the benefits and challenges of repurposing electric vehicle (EV) batteries for stationary storage after they have completed their first life in a vehicle. EV battery recycling has received more attention than the opportunity to first repurpose EV batteries. EV battery repurposing extends the useful life of the battery, reducing both overall greenhouse gas emissions and the need for new mining. Many policy opportunities exist at the federal and state level to facilitate repurposing, including, most importantly, policies that increase access to crucial battery data for repurposers.

This brief was produced with the support of GAIA, a global network working toward a just, waste-free world without incineration. A version of this brief was initially prepared for a GAIA-hosted workshop in April 2025, focused on environmental justice standards for EV battery repurposing. This brief reflects insights from that workshop as well as interviews with key industry and policy stakeholders. While it touches on the benefits and considerations of EV battery repurposing to communities abroad, the focus is on U.S. domestic industry and policy opportunities.

Key takeaways

- Batteries taken out of electric vehicles are often suitable for use in stationary storage as they can retain upward of 80% of their original capacity.
- Repurposing used electric vehicle batteries into stationary storage reduces overall greenhouse gas emissions and the environmental impact from mining and manufacturing while providing a potentially more affordable energy storage option.
- Repurposed electric vehicle battery storage systems are not suitable for every storage application and are best suited for backup power and, if battery health is properly managed, storage for solar energy at utility- and commercial-level facilities.
- The repurposing industry is new and faces barriers to large-scale adoption. These include the complexities of changing battery chemistries, logistical and financial burdens to transport used batteries, fire risk, issues with battery disassembly, the safety certification processes, and most importantly, access to data on the battery and its first life in the vehicle.
- Policy opportunities that would enable greater electric vehicle battery repurposing include the following:
 - Require access to battery management software data from the original vehicle for repurposers and other owners of second-life electric vehicle batteries.
 - Establish a battery passport to share data about the battery, including state of health information.
 - Update safety certification processes to ease compliance and limit costs.

- Establish some level of extended responsibility for vehicle manufacturers for the end-of-life considerations of EV batteries to ensure that repurposing is considered.
- Establish design standards for electric vehicle batteries that enable easier and safer repurposing.
- Update hazardous waste and material classifications.
- Battery minerals are a scarce resource. But despite the financial and environmental benefits of battery repurposing, battery repurposers lack a standardized framework to follow.

Introduction

The car market is rapidly electrifying, with millions of electric vehicles (EVs) already on U.S. roads and many millions more expected in the coming years and decades. As these vehicles reach end of life (EOL), their batteries often retain upward of 80% of their original capacity (Zhu et al. 2021). These batteries may no longer power passenger vehicles effectively due to the reduced driving range from the lower battery capacity and the high performance of batteries needed by EVs. However, batteries that meet certain safety and performance specifications can still be valuable in stationary storage applications, including energy storage for electricity produced from wind and solar, backup power for homes and businesses, and energy storage for EV charging stations. Stationary storage requires less energy density and generally has lower performance requirements than EVs, making it suitable for the second life of EV batteries.

Repurposers often purchase used EV batteries with little accompanying data from the automaker or first user, making their job much harder. Crucial for repurposing, data on batteries allow repurposers to decide which batteries to repurpose, which batteries should be grouped together, and which should be recycled. Currently, no requirements exist in the United States to share battery data with repurposers, specify what the data should include, or ensure data accuracy. There are also no requirements to reuse, repurpose, or recycle batteries at the end of their first life. Widespread EV battery repurposing is unlikely without a framework around battery data sharing and requirements to assess viability of battery repurposing before recycling.

This brief is directed at state and federal policymakers who want to strengthen the market for battery repurposing and ensure EV batteries are considered for repurposing at the end of their lives in EVs. This brief can help inform ongoing discussions about EOL possibilities for EV batteries in addition to recycling. It lays out the steps involved in repurposing used EV batteries, explores the potential markets for post-consumer EV batteries, identifies barriers to adoption, and concludes with a discussion of policy opportunities to support greater use of post-consumer batteries for storage applications. The findings of this brief are informed by interviews with industry players, researchers, and advocates, as well as discussions among these stakeholders at a recent convening.

Key terms

Battery capacity: The capacity of a battery is the total amount of electrical energy that it can store. Battery capacity declines over time as the battery materials degrade, and so the capacity is often expressed as a percentage of the rated capacity set by the manufacturer.

Battery cell, module, and pack: A battery cell is the smallest unit of the battery, often in the form of cylinders or pouches, which performs the essential function of storing and releasing energy. Multiple

cells are combined to make a module, which then forms the building blocks of a vehicle's battery pack or complete storage system. Additional components like battery management systems, thermal management, and cooling systems can be added at both the module and pack level.

Battery cycling: A battery cycle consists of fully charging and discharging the battery. The number of cycles that a battery can complete until it reaches the end of its life is often used to specify a battery's lifespan.

Battery energy storage system (BESS): This system is made up of multiple batteries that store energy for later use, often in conjunction with intermittent sources of renewable energy such as wind and solar.

Battery management system (BMS): The hardware and software of the battery pack monitor and control charging and discharging, monitor temperature, and assess overall health.

Battery passport: This commonly used term describes a policy that allows key manufacturing information on a battery to be accessible throughout the life of the battery and follows the battery to future owners. Data can often be accessed through a QR code on the battery or other unique identifier.

Battery recycling: Different physical or chemical processes break down a battery into its mineral components to be used to create new batteries or other electronics. Unlike reuse and repurposing, recycling does not use the battery or its components for energy storage, instead extracting the materials in the battery for new products.

Battery repurposing: Repurposing means using a post-consumer EV battery for a different application than its original purpose. Repurposing EV battery packs for stationary storage often follows one of two paths: repurposing the entire pack or breaking down the pack and repurposing its modules.

Battery reuse: A second-life battery may be used for a similar purpose as its first life, such as powering a golf cart.

Behind-the-meter: These systems or technologies exist on the customer side of the electrical meter and are not owned by the utility: for example, onsite solar production or backup power at a commercial facility.

Front-of-the-meter: These systems or technologies exist on the utility side of the electrical meter and are owned by the utility itself or an energy producer. These generally include energy generation and utility energy storage.

Post-consumer EV batteries: These EV batteries were initially used in an EV and have been removed from the vehicle.

Second-life batteries: The design and operation of these post-consumer EV batteries has been altered for an application other than the original one, such as battery energy storage.

State of health (SOH): This term for the health of a battery refers to the percentage of original energy capacity remaining and other indicators of degradation further discussed in the section on "Accessing EV battery information," below.

Why repurpose EV batteries?

Greater use of post-consumer batteries can displace the need for new batteries for storage applications, reducing emissions and mining while providing a lower-cost storage option for many communities, especially low-income ones. While EV batteries should ultimately be recycled to reduce the need for newly mined materials, repurposing can be a key part of the life cycle of the battery. In fact, repurposing before recycling has been shown to reduce the life-cycle impacts of the battery materials (Dunn et al.

2023). Ensuring the highest value use of these resource- and energy-intensive battery materials is important to a sustainable transition to electrified transportation.

Battery energy storage systems using repurposed EV batteries have numerous benefits, including lower resource and energy use, lower levels of hazardous waste, less harm to ecosystems, lower greenhouse gas emissions compared to new manufacturing and recycling, and more affordable energy storage that brings the benefits of clean energy to more families, including low-income ones.

Lower overall greenhouse gas emissions

Repurposing EV batteries for stationary storage extends the useful life of those batteries, meaning the initial emissions needed to produce them are spread out over more years of use. The process of recycling emits more pollutants than repurposing, so delaying it until completely necessary—that is, when the battery is no longer useful for any application—reduces overall emissions compared to a scenario where younger batteries are frequently recycled to make new batteries (Dunn et al. 2023).

Reducing new battery production and mining

Repurposing EV batteries for stationary storage reduces the need for new battery production, lowering the emissions and impacts of battery manufacturing as well as mineral mining and processing (by reducing new mineral demand). This can benefit environmental justice (EJ) communities¹ both domestically and abroad that are impacted by mining and battery manufacturing. Recycling batteries at the end of their life can also help, but reusing or repurposing EV batteries before they are recycled is more beneficial because repurposing batteries first limits the mining impacts (including considerable impacts on local ecosystems) and production emissions needed to produce new batteries for stationary storage (Davis and Lumkong 2024; Dunn et al. 2023).

Greater resilience

Repurposed battery systems can provide a lower-cost backup power option for families and communities to improve resilience in the face of increasingly extreme weather events. If paired with solar or wind, these systems can also provide clean power that is potentially independent of the grid. Furthermore, EJ communities often experience the worst consequences of extreme weather and are less prepared for the power outages that result, so the benefits of reduced-cost energy storage are even greater. Repurposed EV battery systems can provide a more affordable energy storage option, expanding access to more communities (Mango and Tym 2025).

Lower energy costs

Repurposed batteries paired with solar can also reduce energy costs and provide benefits outside of natural disasters. Solar energy can already provide low-cost energy to families and communities, but paired with affordable storage systems, those benefits can be extended by storing abundant daytime solar energy for use at night. Low-income households face an energy burden relative to income three times that of other households, with a significant portion often comprising electricity. These systems at scale can reduce costs up to 60% compared to providing adequate power at all times from gas or other options from the utility (Mango and Tym 2025; Hledik and Peters 2023).

Reduces emissions in low-income communities

Storing wind and solar energy in a battery energy storage system (BESS) for use during peak times can significantly reduce emissions from peaker plants, or the gas plants that are generally used to provide

¹ *Environmental justice communities* generally refers to communities that bear a disproportionate burden of environmental harms, such as poor air quality, and suffer negative impacts as a result.

electricity when demand is highest. These plants can be highly polluting and are disproportionately located near low-income communities. Using these plants less or replacing them entirely will provide significant air quality and cost benefits to these communities. Affordable repurposed EV battery storage systems can accelerate these investments (Richardson 2019).

How an EV battery is repurposed into a BESS

Collection and shipping

The United States has no centralized system for recovering EV batteries, so collecting batteries at the end of life in the vehicle is complex, fragmented, and inconsistent, with some stakeholders describing the current landscape as the “wild west.” EV batteries are sourced by repurposing companies, generally small startups, on an ad-hoc basis, though some have developed relationships with original equipment manufacturers (OEMs) who are motivated to sell these post-consumer batteries or offload recalled or unused batteries. Private partnerships may ease issues around collection, such as closed-loop systems that bring together battery manufacturers, vehicle OEMs, and repurposers (Jung 2024).

Transporting post-consumer batteries from vehicles to repurposers presents significant challenges and costs. EV battery packs are heavy, making them expensive to transport over long distances. A limited number of automotive dismantlers and repurposers are scattered throughout the United States. Shipping heavy battery packs around the country to be dismantled and repurposed also contributes to greenhouse gas emissions, limiting the emissions benefits of repurposing. Post-consumer batteries are also classified as hazardous materials when they are outside the vehicle, adding complications and costs to comply with hazardous material regulations. These batteries are at risk of leaking toxic and flammable substances and must be handled and transported carefully, with additional regulations on logistics companies (Jung 2024; Tankou, Bieker, and Hall 2023).

Accessing EV battery information

Deciding whether a post-consumer battery pack can be repurposed requires as much information as possible. This information also facilitates the repurposing process. Assessing whether a battery is fit for repurposing requires access to basic information on the battery’s physical integrity, chemistry, performance characteristics at the time of manufacture, and the state of health (SOH) before removal from the vehicle. However, these key pieces of information are not always all available or are only available to a limited number of stakeholders.

OEMs are concerned about protecting what they see as proprietary information, including the data and access to their proprietary battery management systems (BMS). This hinders the ability of repurposers or other third-party actors to make the best use of post-consumer batteries. Data access is also an important environmental justice issue, as lack of access can leave disadvantaged communities and countries with less ability and capital to develop their own systems to verify battery data and do their own testing to fill in data gaps (De Brouckere and Moon 2024)

Key information that is necessary for repurposers includes

- Labeling information: manufacturer information, battery type, production date and location, capacity, hazardous substances
- Dismantling information: detailed composition, replacement parts, dismantling instructions, safety information

- Composition: chemistry, carbon footprint, sourcing, responsible sourcing information, expected lifetime
- State of health: performance, remaining capacity, history of accidents or other malfunctions, history of extreme temperature (De Brouckere and Moon 2024).
- UL and other safety testing data

Key considerations for data access include

- Data detail and format
- The ownership of the data and the restrictions on the use of the data
- Any potential costs for the data

Open-access data on EV batteries also allow for safer handling of used EV batteries. Health and safety in the EOL processes for batteries is a major EJ issue, especially in the Global South where electronic waste has historically been shipped and safety standards are generally lower. Data access that is open to all will also support the sizeable repair and repurposing industry abroad, helping those communities with both economic opportunities and affordable energy storage options.

Repurposing the EV battery

The four main steps to repurpose post-consumer EV batteries are assessing the battery's SOH, evaluating the battery's viability, deciding on the configuration, and reassembly. Further details on these steps are as follows:

1. **Assessing the SOH of the battery:** Evaluating the SOH of the battery is the main step to determine whether a battery can be repurposed. If the battery is too degraded, then it is likely not a candidate for repurposing and should be recycled. Information on the battery's first life in the EV from the vehicle's BMS as well as additional testing will likely be necessary. Preferably, this step can occur before purchasing and shipping of a battery.
2. **Evaluating the battery's viability for repurposing:** After initial SOH assessment and evaluation, further evaluation is necessary to determine the battery's characteristics and the potential for second-life purposes. This can include evaluating the configuration of the pack and the ease with which it can be disassembled if desired.
3. **Deciding on the configuration:** At this stage, the repurposer can decide what is the optimal use of the post-consumer battery pack and how much disassembly must be done. The battery pack could be used whole, requiring little additional investment but limiting flexibility in the final storage system and requiring communication with the pack's BMS. The pack can also be disassembled and the modules or cells used in another storage system. This process requires more processing and know-how, generally involving new software and thermal management systems to be added by the repurposer, because dismantling modifies the pack's original systems. However, these new systems can be more customized and suitable for more storage applications.
4. **Reassembly:** The final stage involves the actual reassembly either as a series of whole battery packs or as a BESS made up of modules and cells from the original battery pack (Davis and Lumkong 2024).

Markets for second-life EV batteries

Repurposed EV batteries can fulfill many of the varied uses for batteries. However, new battery energy storage systems (BESS) may be better suited for some use cases while repurposed EV battery systems may be better suited for others. Different use cases have different required specifications and customers may have different preferences or risk tolerances that may favor one storage system or another. Table 1 provides an overview of the current potential applications for second-life EV battery storage systems in the United States and their suitability, which can vary depending on the BESS used, including how it was designed by the repurposer and how it is being managed while in use. For example, the ability to manage the health of the BESS effectively while in use can allow for higher performance and greater suitability for more intensive applications. These or additional applications could also become more suitable in the future as a result of policy opportunities described below. Additional information on the markets for second-life EV battery storage systems can be found in Appendix A.

Table 1. Summary of BESS applications and their suitability for second-life EV battery storage systems

Application	Description	Suitability for second-life EV batteries
Commercial backup power	BESS that are located at commercial spaces to provide backup power in the case of natural disaster or power outage	High suitability: BESS used for backup power are used infrequently so the disadvantages of second-life batteries are less relevant; there is limited cycling
Deferring grid upgrades	BESS that are strategically placed to defer the need to upgrade distribution or transmission infrastructure that would be necessary to serve growing electricity supplies or demands, saving utilities money	Moderate suitability: If the project values low cost for the BESS and the BESS does not need to be used frequently—i.e., infrequent cycling—then second-life EV batteries can be suitable. Specifications of BESS using repurposed batteries will matter, however, with greater monitoring and management of the battery to minimize degradation over time.
Grid-scale storage	BESS that are often used in conjunction with wind and solar projects to store power for later use that day	Moderate suitability: Depending on the project's specifications, BESS made with second-life EV batteries may be suitable. Projects that value lower cost and where the BESS does not need to be used daily are most suitable. Similar to deferring grid upgrades, the ability to monitor and manage battery health will minimize degradation and improve suitability for this application.
Residential backup power	BESS that are located at residences to provide backup power in the case of natural disaster or power outage	Moderate suitability: This application has suitability similar to commercial settings, but the perception that second-life batteries are more prone to fires may limit their uptake in residential settings.

Application	Description	Suitability for second-life EV batteries
Storage for EV charging stations	BESS colocated with EV charging stations to limit the electricity pulled from the grid, limiting expensive demand charges	Moderate suitability: This depends on how frequently the BESS is needed, i.e., how often there is significant EV charging demand that needs to be supplemented by the BESS to avoid demand charges. If the EV station infrequently incurs demand charges, then second-life systems can be advantageous.
Grid ancillary services	Major ancillary service is frequency regulation where batteries provide or store electricity rapidly to ensure electricity demand and supply are perfectly balanced, assuring grid stability.	Low suitability: Ancillary services require frequent cycling—that is, where the battery is charged and discharged frequently—making them unsuitable for second-life battery systems. Second-life batteries are already degraded and can become obsolete faster with more cycling.
Storage for onsite solar	Behind-the-meter storage at residential or commercial settings that store onsite solar production	Low suitability: Solar storage often involves daily cycling, where excess daytime solar electricity production is stored and used in the evening and overnight. This frequent cycling is less suited to second-life batteries. Also, these BESS, especially in residential settings, tend to be small and benefit from the economies of scales of production possible with new BESS production.

Barriers to repurposed EV battery storage

A number of barriers could limit the viability of second-life EV battery storage systems, and the biggest barriers are those that limit their cost competitiveness. If the repurposed BESS is not more affordable, most customers would likely not choose it over a new BESS. Repurposed BESS need a cost advantage to compensate for any real or perceived disadvantages of a second-life system, such as shorter lifespan, reduced performance, or increased fire risk. Several reasons why a second-life system may not have a cost advantage are detailed below.

Changing battery chemistry and technology

The lithium-ion battery market is rapidly evolving, with continued innovation and price reductions, meaning that repurposed EV battery systems must be cost-competitive enough to make up for the perceptions of being lower performing (due to the age of the batteries) and generally using older technology. Post-consumer batteries may have drastically different chemistries and other characteristics compared to new batteries, so storage customers who care the most about the latest technology may not choose a repurposed BESS. As battery technology evolves, repurposers will need to keep up to date on the changes to be able to repurpose batteries effectively. Batteries are not only getting more advanced but also cheaper, meaning the cost advantage of repurposed systems over new systems will likely decline over time (BNEF 2024). Repurposers must also compete with recyclers in addition to companies selling new BESS.

Currently, most EV batteries produced for use in the United States are nickel-manganese-cobalt (NMC) batteries, which are expensive to produce due to the high-value minerals they use but are very energy dense and well suited for passenger EVs. However, these batteries' high value mineral contents are desirable to recyclers, who are competitors to repurposers for used batteries. Ultimately, the used batteries will go to the actor with the best business model who can offer the most money.

The U.S. EV market is expected to move toward lithium iron phosphate (LFP) batteries because they are more affordable and safer. They do have worse energy density, a major disadvantage for EVs, but this has improved in recent years (Moller et al. 2024). This shift is already happening to some extent in the new BESS market, in part because higher energy density (amount of electricity per kilogram of battery) is not as necessary in stationary storage as in vehicles (Spector 2025). The move toward LFP batteries in EVs may benefit the repurposing industry, as LFP batteries have significantly lower value to recyclers: Their contents are lower value and they tend to be more challenging to recycle (Brinn 2023; Shah 2025). LFP batteries usually also have lower fire risk, so they are even more suited for repurposed battery systems, where concerns over safety are often higher. Without significant competition from recyclers, repurposers may be able to purchase used LFP batteries very affordably.

Challenges to access information to evaluate state of health

Getting an accurate sense of the SOH of the pack is paramount, as without this information it is impossible to assess whether a battery can be repurposed. Basic information needed by a repurposer, like the battery's initial voltage and capacity and its chemical composition, are not always readily supplied by the OEM. Data regarding the SOH, such as current capacity, history of charging and discharging, and temperature, are not readily available either without access to the pack's BMS, which may not be provided by the OEM, requiring often expensive and time-consuming testing or reverse engineering of the BMS (Tankou, Bieker, and Hall 2023; Zhu et al. 2021). One standard used to do testing is UL 1974, which lays out procedures to test used batteries to gather critical information for the purposes of battery reuse. However, this procedure can prove quite costly, with one estimate putting it at 30% of the used battery's cost (Rejoule n.d.).

While access to a vehicle's BMS data could provide some of this information if made available to repurposers, these data will not eliminate the need for further testing by repurposers, in part because a vehicle's BMS will likely never track all the data necessary for repurposing, especially at the module or cell level. OEMs have little incentive to track the breadth and depth of data needed by repurposers, in part because they are far less concerned about the second life of the battery or how individual battery modules or cells would perform if the pack were disassembled.

Batteries are costly and challenging to assess, disassemble, and sort

The use of post-consumer EV battery packs for BESS can be done in two distinct ways: using the battery pack in its entirety from a vehicle without any physical modifications, or breaking down the used battery pack and reassembling individual cells or, more commonly, modules in a BESS.

Repurposing through pack disassembly

Disassembling battery packs safely involves significant costs, especially when dealing with battery packs that are from different automakers or OEMs. This process is also hindered by a move toward integrating battery packs into the structure of the vehicle, as well as general safety precautions necessary when working with high voltage batteries (Tankou, Bieker, and Hall 2023). Further, battery packs are generally not designed to be disassembled easily, may require specialized or proprietary tools, and can present

health and safety risks for the technicians, who may also lack the necessary information from the OEM on how to disassemble a pack safely (Reyes and Davis 2024)

After disassembly, one would need to sort through the modules to pair ones together that are similar in SOH, performance characteristics, and chemistry to ensure optimal performance in the repurposed BESS. The repurposer can also isolate cells or modules in the original pack that had issues (Davis and Lumkong 2024; Zhu et al. 2021). This requires the technical know-how to accurately assess all of this information to ensure that the new system is as homogenous as possible: it will in many ways perform only as well as its weakest link (Montes et al. 2022; Zhu et al. 2021).

The cost of this process may mean these BESS are no longer cost competitive, although some of these costs may decline over time with greater expertise (Zhu et al. 2021; Tankou, Bieker, and Hall 2023). However, these BESS are not dependent on access to the original pack's BMS software and can be customized for the customer.

Repurposing using the entire pack

BESS that use a used EV pack in its entirety largely avoid the issues and costs associated with disassembly and reassembly, but they are dependent on understanding the pack's software system. A repurposer would need to develop software that can override or control the OEM's BMS and that can spot issues within a battery pack, such as damaged cells or variations in SOH. An OEM's BMS is a key piece of intellectual property that is closely held and constantly updated, meaning repurposers either need agreements with these OEMs to have access or need to reverse engineer this software in some way. This strategy is also dependent on getting a thorough understanding of the battery pack itself, especially its SOH and condition.

Safety testing and certification can be expensive

Confidence that the repurposed battery systems will be safe is paramount for customers and regulators and generally requires testing. Currently, safety regulators and permitting agencies in the United States and Canada generally only accept the UL standards for second-life EV batteries and battery storage systems (Zhu et al. 2021). Certification by UL is a critical step for a repurposer, but their requirements can add significant costs and challenges, some of which could be avoided.

There are four relevant certifications for repurposers: UL 1973, 1974², 9540, and 9540A. UL 1973 is the general standard certifying that a BESS is safe to use, while UL 1974 is specific to repurposing EV batteries for BESS and details disassembly, testing, and reassembly procedures. UL 9540 and 9540A are fire and safety certifications that are generally required by fire codes for a BESS to receive a use permit. UL 1973 and 1974 are generally prerequisites to 9540 and 9540A and are therefore critical to widespread permitting and use of repurposed BESS.

These certifications have a number of issues, with UL 1974 in particular creating a major barrier for repurposers (RePurpose Energy 2025):

- **Requires cooperation from the OEMs:** UL requires certain pieces of information, some potentially unnecessary, about the EOL battery that must be directly received from the OEM, even if some of this information is publicly available. For example, if the OEM does not provide the battery datasheet to the lab performing the UL testing, certification is impossible. This system makes OEMs into gatekeepers in the repurposing industry, potentially limiting

² UL 1973 and 1974 are based on UL's numbering convention and not indicative of the years 1973 or 1974.

competition. Mandating data sharing from OEMs or some other policy requiring open and timely sharing of these data by OEMs could mitigate this issue.

- **Certification processes specific to every cell type:** Certification processes can be time-consuming and expensive and must be repeated for each different cell type even if they are largely the same, such as different model years of the same vehicle and battery. This means even small, nonconsequential changes in batteries would require redoing the entire certification process, severely limiting scalability and profitability for repurposers.
- **Inefficient testing procedures:** UL 1974 includes testing requirements that can be too prescriptive and contain redundant elements, leading to increased testing times when more efficient testing methods exist. Allowing for alternative testing methods, including many developed by repurposers themselves, could save considerable time and money.
- **Enforcement of UL standards is not standardized:** UL develops the standards, but separate labs actually conduct the testing. Their enforcement of UL standards, sometimes vaguely defined by UL, can vary significantly. The length of time these labs take to run the tests and the assessment can vary significantly and should be monitored by UL.

These certifications are not only a critical step for the repurposing industry but a major cost: RePurpose Energy say it costs them roughly \$1.2 million for each battery type to run the necessary tests and receive all four certifications. That figure would need to be paid again for additional cell types (RePurpose Energy 2025). It is possible to certify entire facilities that produce repurposed BESS, not just individual products, but this has proven to be even more challenging—only one facility as of 2023 has received certification (Resendiz 2023). Certifying a facility involves continuous auditing by UL, which requires significant upfront and ongoing investment, and can be a challenge if the facility does not have consistent production of repurposed BESS to audit. This process can only succeed if the repurposer has the ability to scale up production, which is a significant hurdle for the current industry.

Collection and transportation issues

Currently, repurposers face logistical challenges to find EOL batteries to purchase. This is in part because no policy details responsibility for the battery at the end of its first life, which would help enable a marketplace. In addition, the supply of EOL batteries is limited for now (Tankou, Bieker, and Hall 2023). As a result, some repurposers rely on relationships with OEMs to secure batteries, including batteries that have been recalled or excess batteries held by the OEM so they can meet their battery warranty obligations. However, over time the supply of used batteries that have reached EOL in vehicles should grow.

EV batteries are also challenging to transport due to their weight as well as safety and other restrictions. Transportation costs can be significant: one metanalysis of studies from across the world found that 70% of studies on EV battery reuse and recycling cited challenges with transportation costs, which could range from 5% to 63% of the total project costs (Slattery, Dunn, and Kendall 2021). EV batteries are classified as hazardous materials due to their chemical composition and fire risk, which adds additional requirements for transportation, increasing costs and logistical burdens (Tankou, Bieker, and Hall 2023; McNamara 2023).

Perceived risk of lower reliability and safety

Another challenge in the current repurposing industry is that most of the actors are relatively new and have limited track records; some customers may be hesitant to purchase their systems as a result. Customers may be concerned that the repurposer may not be able to provide adequate customer

service or ongoing maintenance. Customers who emphasize reliability and risk minimization may not purchase these systems if they believe they will not receive permitting and regulatory approval to operate them. Customers may also hesitate to purchase a repurposed storage system due to fear that it will have higher fire risks than new storage systems—which come with their own perceived fire risks, especially after the January 2025 fire at a battery storage facility in Moss Landing, California (Spector 2025). A certain level of uncertainty comes with repurposed EV batteries, especially when there is limited knowledge about the battery’s first life in a vehicle. The perception that the repurposed systems are riskier may limit their uptake.

Utilities and other grid actors emphasize reliability and tend to be risk averse. The downside of a BESS failing and compromising the grid’s reliability is high, so these actors tend to be more conservative and may prefer a new BESS that is better understood and has a longer track record than a repurposed system from a newer company. Understanding the potential risk of a product and using a proven system is also important when receiving approval for a project from a state’s utility commission.

Policy options

Actions at the federal and state level can reduce the obstacles to wider use of repurposed EV battery storage systems and allow more of these batteries to be considered for repurposing before they are recycled. Key steps to more widespread repurposing of EV batteries include

- Require access to BMS data for repurposers and other owners of second-life EV batteries
- Establish a battery passport to share data about the battery, including SOH information
- Update the UL certification process to ease compliance and limit costs
- Establish extended responsibility of OEMs for the EOL considerations of EV batteries, such as a waste hierarchy outlining when batteries should be repurposed and prohibitions on landfilling, incinerating, or exporting EV batteries abroad (where they will likely not be handled responsibly)
- Establish design standards for EV batteries that enable easier and safer repurposing
- Update hazardous waste and material classifications

Data access policies

Understanding the current SOH and history of an EV battery at the end of its life in a vehicle is critical to repurposing it for a second use. The more data a repurposer has, the better. The data allow repurposers to match batteries that are as similar as possible in chemistry, performance characteristics, and SOH. Greater data access reduces the need for testing, saving time and money, and improves transparency and equity.

Access to BMS data

One key source of data that is not readily available is the data captured by the vehicle’s BMS. Having historical data on the battery can add invaluable insights to any testing that can be done when the battery is taken out of the vehicle. Making these data available to repurposers could save time and money on testing to determine repurposing options and match like battery packs or modules. However, the software and the data it logs over the course of the EV’s life are heavily guarded by the OEMs; the software especially is considered a key piece of intellectual property.

A policy requiring that select data points logged by the BMS be shared with the second users of a battery, potentially as part of a larger policy (as described below) could allow repurposers to access the data they need most while limiting risks for the OEMs. The European Union’s battery regulations require access to standardized BMS data, potentially allowing access to considerable amounts of SOH data for repurposers, but these regulations lack detailed technical guidelines for data collection and formatting (Gode, LoSciuto, and Nassar 2025).

Another important policy would detail what data all EVs must track in their BMS and make available to second users. An impartial public or private technical group may be necessary to determine what data must be shared. Regulations should also address the risk that BMS data on SOH could be tampered with (Gode, LoSciuto, and Nassar 2025; Rajbhandari 2022).

Key considerations:

- What is the minimum dataset that repurposers would need?
- What group would determine this dataset?
- How would the data be shared and who would have access?

Battery passport

A battery passport policy generally requires key manufacturing information about a battery to be easily accessible throughout its life cycle through a QR code or a unique identifier. This information could include the battery chemistry and other materials used, the rated specifications such as voltage and expected number of cycles, the manufacturing site and model, and information on how to handle the battery safely. California’s Advanced Clean Cars II regulation requires many of these to be included or made available through labeling requirements and is modeled off the EU’s battery laws (Brinn 2023). This policy is also a possible conduit for OEMs to share the BMS data described above.

Benefits:

- Cost savings in assessing battery health and potential for repurposing if SOH data are included
- Facilitates faster sorting and grouping of EOL batteries
- Allows for tracking of the battery throughout its potentially many lives
- Improves transparency
- Lays groundwork for robust market and supply of EOL batteries

Risks:

- Could include information the OEM does not wish to share
- Requires upfront investment to establish information sharing systems and determine data standards

One important question is whether a battery passport or other data sharing policy would include SOH information. Information regarding the current SOH of the battery and its history of charging and potentially overheating would be invaluable for second users as they evaluate used batteries for storage applications. This information, however, is generally closely guarded by OEMs and likely would only be provided if required, or possibly through a partnership between an OEM and repurposer. The EU battery passport law requires some SOH information be made available to some stakeholders in the future. The information required includes remaining capacity, charging and discharging rate, and temperature information (TuvSud 2024). In the United States, a federal battery passport system that includes SOH

information to be made available to repurposers would significantly lower barriers to EV battery repurposing.

Safety certification updates

Safety certification ensures the safety of repurposed battery systems for buyers and permitting agencies. In the United States, the certification process is done by UL Solutions. UL or a government entity could make the process less onerous and expensive with updates including

- Requiring OEMs to provide to UL in a timely manner the necessary data to complete the various certification processes; alternatively, UL could rely on data provided through testing by the applicant
- Allowing certifications for repurposers to be extended across battery types that are significantly similar, so that the process does not need to be repeated for inconsequential differences
- Allowing alternative testing methods, including the many developed by repurposers themselves
- Enforcing consistency across the independent labs that conduct the testing involved in the certifications

Extended producer responsibility (EPR)

Extended producer responsibility policies extend prolong the OEM's responsibility for the battery until EOL. It primarily shifts the cost of waste management and EOL considerations from the taxpayer or public more generally to the producer and seeks to improve the design and social and environmental performance of the products covered (De Brouckere, Moon, and Jung 2025). Such a policy would ensure that the responsibility for the battery at the end of its first life is clear and decisions around reuse and recycling can be made without confusion over who is liable.

EPR is not a universally defined term. For this discussion, it is considered any policy that requires OEMs to manage the EV battery at the end of its first life when it is removed from the vehicle and mandates some degree of reuse, repurposing, or recycling of all EV batteries. Other key elements of a potential policy include a waste hierarchy, where repurposing is considered for EV batteries before recycling, along with a ban on landfilling, incinerating, or exporting EV batteries abroad. An EPR policy can also include mandates or targets around collection, reuse, repurposing, and recycling rates and recycling mineral recovery rates as well.

The only jurisdiction in the United States with an EV battery EPR policy is New Jersey, approved in 2024, but many other states like California, Nevada, Washington, and New Mexico have considered EPR or similar programs. New Jersey's program outlaws the disposal of EV batteries in landfills and requires producers to develop waste management plans and take-back programs to collect EV batteries at EOL (Crowell 2024). Currently, no federal EPR policy or other policy requires recycling or repurposing of EOL EV batteries, so the United States could end up with a patchwork of requirements for OEMs as states continue to adopt their own policies.

Some state proposals have included a waste hierarchy that states that EOL batteries should be considered for reuse, repurposing, or recycling, although they do not place reuse or repurposing above recycling. These proposals also do not require any testing of EOL batteries to assess whether they are good candidates for repurposing or setting up of protocols for this testing. In the United States, EPR policies in general have not historically done a good job at promoting better product designs that enable reuse or repurposing at the end of their first life.

Benefits:

- Can facilitate a market for EOL batteries, reducing frictions between supply chain actors such as battery producers, remanufacturers, repurposers, and salvagers
- Ideally, incentivizes OEMs to think proactively about battery reuse and recycling during the design and production phase, reducing disassembly costs and potentially easing data sharing

Risks:

- Could increase battery costs by adding additional requirements for OEMs to develop collection programs and support recycling, reuse, and repurposing efforts
- Could disrupt current operations of salvage companies (McNamara 2023)

Key considerations:

- **Structure of the EPR:** Many EPR policies have Producer Responsibility Organizations (PRO) that manage the process and are funded and run collectively by the producers. However, this setup may be less suited for EV batteries, in part because there are fewer producers, who may want more flexibility in meeting their requirements and less centralization.
- **Oversight and compliance:** Key questions include how oversight will be assured and who will be responsible for oversight, and possibly also who will enforce consideration of repurposing before recycling, which may be challenging. Compliance with targets and reporting on collection, repurposing, and recycling rates also need to be addressed.
- **Scope of responsibility:** A major consideration is whether OEMs will still have some level of responsibility after an EV battery is repurposed, which they generally oppose. Other important questions include what role the OEM will play in facilitating the second-life and recycling market, and how open the access will be to these batteries
- **Environmentally friendly design:** Incentives in an EPR for the OEM to design the batteries in a way to make reuse, repurposing, and recycling easier would be very beneficial and should be considered in developing the EPR policy.
- **Testing:** An important consideration for an EPR policy is whether testing of EOL batteries is mandated. If OEMs were required to do some SOH testing and reporting, or to share BMS data, the market for these batteries could improve significantly and the repurposing industry could benefit, but this could prove onerous for OEMs and would depend on the specific reporting requirements.

Standards for battery design

As mentioned above, battery design standards could enable easier repurposing by limiting the variability of batteries and making it easier for repurposers to develop best practices to handle and disassemble EOL batteries. Batteries are not designed to be disassembled, which leads to significant costs and limits the possibility of repurposing. Standards could be developed federally or by an industry body and could include the characteristics discussed in the paragraph below (Reyes and Davis 2024). These efforts would likely face strong opposition from OEMs, who do not want to be limited in the designs they can use and may lose some competitive advantage.

Some key aspects of a design standard that would benefit repurposers include the use of standardized parts and a more modular design for battery packs. Both make the disassembly process easier: Standardized parts are better understood than proprietary, OEM-specific parts, and modular designs

facilitate removal. Less, or more selective, use of adhesives can also aid in the disassembly process. Reducing the use of toxic substances can lower handling costs and improve the health and safety of the disassemblers, as well as communities in the Global South where batteries could end up. The main risk of design standards is that they could limit battery innovations and put additional costs on OEMs.

Hazardous material and waste classifications

Currently, EV batteries outside of a vehicle are classified as hazardous waste by the Environmental Protection Agency (EPA) under the Resources Conservation and Recovery Act, and by the Department of Transportation (DOT) as a hazardous material under the hazardous materials regulations. These classifications add cost and complexity to the transportation process and may not be well suited for these batteries, especially those with significant capacity remaining that may not be considered “waste.” A separate EV battery–specific classification at the federal level could go a long way toward easing transportation costs and facilitating the repurposed EV battery market (Brinn 2023; McNamara 2023). The EPA is planning to propose rules for a separate waste categorization for lithium-ion batteries, but the exact requirements have yet to be released (U.S. EPA 2023).

Conclusion

EV battery repurposing can provide more affordable solutions to meet our storage needs while improving the sustainability of our battery supply chain. Repurposing can extend the life of the battery beyond the first use in the vehicle and give us greater value from the mining and manufacturing impacts of new batteries. While a storage system incorporating used EV batteries may not be suited for every application, it can potentially provide a more affordable and sustainable option for many customers. However, serious obstacles remain to widespread use and policy is needed to facilitate this market and ensure that it is equitable. Access to battery data is crucial to making repurposing work. A larger policy framework around EV battery circularity is also needed, and repurposing should be a key component.

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Appendix A

Utility grid-scale storage and other front-of-the-meter systems

Grid storage use cases

The largest market for stationary battery storage in the United States is grid-scale storage, which primarily complements wind and solar energy production. These BESS are designed to store electricity when there is excess production, such as in the middle of a sunny day, and release when needed, often in the early evening when electricity demand is high. In the past few years, the United States has seen exponential growth in installations of these systems, which often accompany solar developments. In 2024, 11 gigawatts (GW) of utility energy storage were installed, compared to 7 GW in 2023 and less than 1 GW in 2019 (McCarthy 2025). These systems can be particularly valuable in providing electrical capacity during peak periods: that is, providing electricity to the grid when demand is highest. Electricity generation is often costliest at this time and is frequently met with natural gas generation, so BESS with solar can reduce both emissions and costs (Bowen, Chernyakhovskiy, and Denholm 2019).

Similarly, BESS can also take advantage of differences in the price of electricity throughout a day or longer period of time to generate income by storing electricity when it is cheap and selling when it is expensive: that is, arbitrage. This can improve the economics of renewable energy projects by reducing curtailment. Curtailment occurs when insufficient demand for electricity that could be produced by wind and solar projects means production is intentionally reduced by grid operators to ensure the grid functions properly. However, curtailment reduces the revenue that a renewable energy project can generate and also leaves carbon-free electricity on the table, limiting emissions reduction (Bowen, Chernyakhovskiy, and Denholm 2019).

Two other grid uses of BESS are providing ancillary services and deferring expensive upgrades to transmission and distribution infrastructure. Ancillary services ensure a proper operation of the power grid by establishing a reliable power supply. For a properly functioning grid, electricity demand and supply need to be precisely matched; because batteries can charge and discharge almost instantly, they can meet this need, generating revenue while ensuring grid stability.

The physical infrastructure of the grid must be built to ensure that demand can be met at any time to avoid blackouts. This means that if peak demand is expected to increase, the grid must be built out even if that peak period is very short. BESS can reduce peak demand by providing electricity stored from lower-demand periods closer to where the demand is, meaning less transmission and distribution are needed (Bowen, Chernyakhovskiy, and Denholm 2019).

Second-life battery considerations

Many of the existing second-life systems are for utility storage projects, to which they are well suited. Utility storage is a major market domestically. Numerous utility-scale projects have been established in the United States, with a few funded in part by the Department of Energy, including projects by startup Element Energy, which is partnering with NextEra Energy Resources at one of the latter's wind farms in West Texas (U.S. Department of Energy 2022). Another startup providing repurposed second-life EV battery systems for utility storage is B2U, which used second-life Nissan Leaf batteries to complement a solar farm in Lancaster, California—the largest system in the United States at the time at 28 megawatt-hours (Spector 2021).

Despite the success of these DOE pilot projects, second-life systems may not be as competitive as new for many utility projects, which are often very large (in the tens to hundreds of megawatt-hours).

Systems of this size can be purchased at scale, saving on cost per unit, and can be tailored more specifically to the needs of the utility project. As the largest BESS market, utility projects' needs are a focus for industry and research. Batteries are being developed that are customized for stationary storage and may be more competitive than second-life batteries originally designed for EVs (Spector 2024).

Many utility applications also require significant cycling: If they are connected with solar, for example, they are meant to charge during the day and discharge every evening. Repurposed BESS, or BESS made from repurposed EV batteries, may not be as suitable for this application, given that they are already partially degraded and significant cycling will reduce their longevity and therefore their profitability. Frequency response, where batteries ensure that demand and supply on the grid are matched perfectly, is one application that requires significant cycling and is also not well suited for second-life BESS, which can last as little as one year before being degraded too heavily to be useful anymore. However, more suitable utility applications with less cycling include intraday storage (storage for more than 24 hours) or discharging only during peak periods to limit the need for transmission or distribution upgrades (Engel, Hertzke, and Siccardo 2019).

Residential and commercial storage

The use of BESS at residential and commercial sites is similar to utility projects, although the projects are generally smaller in size and in total will be a smaller share of the BESS market. These systems can similarly complement solar or other renewable energy production, likely onsite production, and reduce the need for power from the grid. This can be beneficial for single-family homes up to large commercial sites such as warehouses or factories. Battery storage can also provide backup power to sites that require an uninterrupted supply, such as hospitals and data centers, and can replace traditional backup generators (Jarbatt et al. 2023).

The needs and priorities of these users are often similar to those of utility-scale project developers. Residential users, in particular, stated in one survey that their top priorities were price and performance, safety and the warranty, and ease and cost of installation or delivery time (Jarbatt et al. 2023). For repurposed BESS to be competitive with new systems, they will need to perform on these characteristics. However, one issue with second-life BESS in residential settings is the perception that these systems are less safe due to wear and tear from heavy use in vehicles. This perception may not be accurate: Second-life batteries may actually be safer in some respects because their lower capacity means a lower risk for thermal runaway (Preger et al. 2022). However, a second-life system would need to be very competitive on price or other factors to overcome the perceived greater threat of fire or other malfunction, given that these systems will be in homes.

Repurposed BESS may be more suited for commercial spaces, because the risks to life from a battery fire are lower than in residential spaces. Additionally, repurposed BESS may be more suited for "medium" sized storage applications of a few hundred to thousand kilowatt-hours that are common for commercial applications. Smaller systems (more suitable for residential settings) benefit from the cost reductions that come from mass production of identical storage solutions that can be easily purchased, installed, and serviced in residences. At the moment, second-life systems tend to be ad hoc, with less standardization between systems produced, presenting challenges to scaling a business selling to residential customers.

Commercial applications that are more suitable for second-life BESS include those that do not require significant cycling, such as backup power or reducing demand on the grid at EV charging stations. Backup power is not used frequently, which means the longevity of second-life BESS (in terms of number

of charging cycles until the system is no longer viable) is less of an issue. Another promising application is in combination with EV charging systems, where batteries can provide extra electricity at peak periods to limit draw from the grid. Typically, utilities levy demand charges on users who pull large amounts of electricity over a short period of time because that strains the grid. EV fast charging stations can end up paying a lot in demand charges if many vehicles are trying to charge at the same time, reducing the profitability of the station. Batteries can supplement the grid at these periods to ensure that the draw from the grid is below the thresholds to trigger demand charges (Walton 2018).