AB2832 Draft: *Barriers and Opportunities*

Logistics

Scope and definition

The logistics subcommittee was formed to focus on activities that facilitate both reuse and recycling, acknowledging that to realize the benefits of either process, batteries must first be safely collected and transported. The activities that fall under the scope of logistics include removal of the battery from vehicle ("dismantling"), testing to determine appropriate next use, collection and sorting, transportation, and tracking.

Barriers to safe and efficient logistics

Capturing out-of-warranty batteries

Many of the barriers identified stem from the decentralized and unregulated nature of the vehicle afterlife market in the United States, and the fact that retired EVs may end up being handled by several different parties who have unequal access to the resources and information necessary to properly manage EoL batteries. One of the concerns mentioned by participants was that once vehicles and/or batteries are out of warranty, it is difficult to track them or control what happens. Given the market-driven nature of the vehicle afterlife industry, returning EOL batteries to a domestic reuse and/or recycling system essentially relies on there being some financial incentive or benefit for doing so to whoever is handling the battery.

Safety

EV batteries are significantly higher voltage than car batteries have been in the past and pose a threat of electrocution if not handled properly. Whoever removes the battery from the vehicle must take certain safety precautions, particularly if the battery is physically damaged. For example, the battery must be drained and disconnected before any work is performed on the vehicle or battery. Facilities should also be equipped with appropriate personal protective equipment (PPE), including but not limited to rubber gloves and boots, high voltage-safe tools, matting, and a safety rescue hook. The other key safety issue is fire. If an EV battery happens to catch fire, it may reach temperatures up to 1000 C due to thermal runaway. Fire damage can be mitigated by keeping a fire safety blanket onsite and by dismantling and storing EVs in an isolated area.

At the same time, the necessity for specialized dismantling creates an opportunity to create skilled jobs within the state of California. To prevent harm and take advantage of the opportunities presented by the EV transition, resources such as information, training, and safety equipment must be widely accessible to anyone who may be in the position to disassemble an EV. Currently, information on handling EVs and hybrids is available from the Auto Recyclers Association and Salvage Wire, a consultancy based in the United Kingdom.

Storage

Because of the safety hazards described above, whoever handles an end-of-life battery must follow certain storage and transport protocols. Storage requirements are defined by the local fire code, as noted in the Relevant Regulations section, and include minimum space requirements and fire suppression capabilities. Storing batteries onsite may present a burden and liability, particularly for smaller facilities that do not have sufficient space to hold batteries for extended periods. This was mentioned as a concern for both auto dismantlers and dealerships. Dealership representatives do not want to become long-term storage sites for batteries, particularly since the majority of EV sales and ultimately returns will take place at dealerships in denser urban areas, where space is scarce and valuable. Meanwhile, dismantlers are concerned about the safety threat posed to their facility and personnel.

Part of the challenge is that while dealerships have connections to the OEM and their collection network, dismantlers may not have information about where to send batteries. Many are currently accumulating them onsite in the absence of a clear directive (cite ARA presentation).

Transportation

As noted in the regulatory landscape section, the party handling the battery must also comply with hazardous materials shipping protocol as specified by DOT, which increases the cost of transportation. Furthermore, damaged batteries are subject to more stringent transport requirements, as specified by paragraph (f) in the DOT Code of Federal Regulations (CFR) §173.185. Specifically, they must be shipped in a United Nations-certified container, which must be custom-ordered from dangerous goods manufacturers at great expense. Estimates of the cost of transportation vary widely but are estimated on average to contribute 40-60% of the overall cost of recycling.

Unlicensed dismantling

According to CA Vehicle Code §11500, it is unlawful for any person to act as an automobile dismantler without having an established place of business, meeting specified requirements, and having a current, valid license or temporary permit issued by the DMV. Licensed dismantlers process an estimated 840,000 of approximately 1.2 million vehicles that reach EOL in California each year. However, an ongoing concern is the rise of unlicensed dismantling in the state. Unlicensed dismantlers acquire most of their vehicles through auto auctions and dismantle them in various locations including repair shops, remote locations, parking lots, industrial lots, and residences (DMV report). This is problematic because unlicensed dismantlers do not take the same precautions when disposing of hazardous materials and fluids.

Unlicensed dismantling is particularly undesirable for EVs given the hazards posed by large-format Lithium batteries when handled incorrectly. In addition, it further complicates the EOL chain of custody and may make it even more difficult to capture retired batteries for reuse and recycling. Participants who represent the dismantling industry identified this issue and are concerned that any added burden imposed on licensed dismantlers will push more vehicles into the unregulated grey market, where it is cheaper to operate.

Infrastructure and capacity gaps

Since EVs are not currently being retired at a large scale, California does not currently have the needed capacity in terms of trained personnel to handle high voltage batteries. Participants also identified a lack of infrastructure for battery disassembly from pack to module.

Regulatory barriers

Participants identified several areas where clarity on existing regulations is desired and discussed the need for alignment between federal and state regulations. Clear instructions on navigating hazardous materials transportation and hazardous waste regulations such as packaging, safety, and storage requirements was emphasized. Participants also mentioned a need for solutions to minimize the cost of compliance, especially for smaller operations.

Universal waste classification

Lithium batteries are classified by DTSC as a universal waste. However, a key point of discussion was defining at what point they become classified as waste, which will affect what activities may be classified as hazardous waste treatment and who may be considered a generator, handler, or treatment facility. This is an issue that affects all subcommittees.

Lack of regulations defining producer responsibility

At present, it is unclear who will coordinate and pay for collection, transportation, and processing. In the absence of extended producer responsibility for EoL batteries (or some alternative mechanism), the system is reliant on the profitability of reuse and/or recycling to incentivize collection.

Information needs

To facilitate an optimal EOL pathway, the parties involved must have access to information about the battery itself, as well as the knowledge and skill to handle it safely.

Condition of battery:

Information about the condition of the battery is necessary to enable the party handling the battery to determine the next appropriate use for the battery, and how to ship it there. Specifically, knowing the state of health (SOH) is necessary to determine whether the battery is most suitable for reuse in a vehicle, repurposing for stationary storage, or recycling. In addition, information about the battery’s history and whether it had been in an accident would alert the handler to the potential of physical damage so they could take the needed precautions.

Battery chemistry:

Knowledge about battery chemistry is most important for recyclers because sorting before recycling makes the material recovery process more efficient. However, this information would also be valuable to the party handling the battery for negotiation purposes, as recyclers may be willing to pay for higher-cobalt chemistries or at least cover the cost of transportation.

Information about how to safely handle batteries

Participants pointed out that OEMs provide training for dealers about how to handle their batteries and vehicles. It was recommended that this sort of information be made accessible and distributed to independent dismantlers, repair shops, and first responders. In addition, it was recommended that agencies provide clear, detailed guidelines on OSHA, storage, and shipping requirements, and make funding available to support videos and other training materials.

Opportunities

Reduced cost and environmental impact of transportation

Addressing the barriers listed above would make the reverse logistics process more efficient by avoiding unnecessary transportation since improved information along the chain of custody would allow relevant stakeholders to send batteries directly to the most appropriate destination. The cost of transportation could also be reduced by facilitating a collection system with strategic infrastructure that enables batteries to be regionally accumulated prior to transport to make the shipment more cost-effective. In addition to making the process more economical, reducing the distance traveled also reduces the overall environmental impact of recycling. Finally, the cost of transportation can be reduced by identifying strategies that ease the cost of regulatory compliance without sacrificing the need for safety.

Increase recycling rates

Improving the collection rate and reducing the cost of transportation would increase the recycling rate for Lithium-ion batteries, which would make the industry more economical by increasing throughput. In turn, this would allow California and the United States to realize the environmental, economic, and social benefits of recovering critical materials from EVs. Participants also pointed out that creating a successful collection program could provide a framework to encourage the recycling of other products such as computers, outdoor power equipment, and solar panels.

Support reuse and repurposing

Reducing the cost of transportation and improving the possibilities for testing and tracking would also support the reuse industry by making it easier to determine which batteries are best suited for reuse. In addition, better information about battery storage would increase safety and avoid unnecessary degradation, which will also support reuse.

Benefits to dismantling industry

In the near term, establishing a robust network and facilitating access to information will provide a solution for people and companies who don't know what to do with stranded battery packs. As more battery packs come offline, the demand for collection and dismantling will create skilled job opportunities within California.

Improved Safety

Better information on proper handling, storage, and shipping protocol will promote safety for all parties involved in end-of-life management. Access to knowledge about the battery's condition will also alert the party handling the battery about the need to follow extra precautions or use specialized packaging.

Reuse

Scope and definition of reuse

Reuse and repurposing of electric vehicle batteries face a number of barriers as well as opportunities and benefits that can be grouped into larger themes. For barriers these include cost, allocation of responsibility, lack of information and data, battery design, and lack of volume for a sustained business plan. For opportunities and benefits these include reduced environmental impacts relative to alternatives, economic opportunities and benefits, provision of energy storage services, and others such as improved traceability, and reduced incentives for planned obsolescence. The following text outlines the barriers and opportunities in greater detail.

Barriers

Cost

For the used batteries to be competitively priced against new batteries they must be offered at a discount, which is difficult to achieve due to the falling costs of new batteries. The main costs of repurposing come from acquiring batteries, testing to determine state of health, and reconfiguring and equipping batteries with a battery management system, thermal management, and other required hardware and software. In addition, battery storage systems must meet certain standards, either because they are mandated by law or expected by the market. The cost of obtaining the necessary certification presents a significant burden for repurposers, who are typically smaller startup companies and do not have the same resources to draw from as OEMs . In addition, the cost of storing batteries onsite, permitting, and complying with the regulations are a strain on the companies, and the added lack of clarity about the regulatory compliance required dissuades actors from the market.

The difficulty in competing with new batteries is exacerbated in California because second-life batteries are not eligible for the CPUC's Self-Generation Incentive Program, which partially subsidizes the cost of new energy storage systems.

Allocation of responsibility

A lack of clarity within the industry of legal obligations and responsibilities when a battery is reused is a barrier to the development of start-ups and partnerships with OEMs. There needs to be a clear understanding of what the costs of repurposing are, including the social and environmental externality costs, and who is responsible (OEMs, EV owners, the government). If a battery is repurposed by a third party and not the OEM, it is unclear if the OEM or the repurposer will be liable if there is an accident. To clearly define ownership to the repurposer will remove liability from the OEM. In the case that the OEM is not responsible, they are also sensitive to negative press and potential reputational risks which will dissuade their participation in aiding repurposing to take place. The current business model does not result in the EVs being secured by the OEM at the EoL unless they are returned due to warranty issues. Currently, the EVs are traveling the same route as the internal combustion engine vehicles at their EoL.

Lack of information or data

Repurposing and refurbishing companies need access to information about the battery's state of health (SoH) to estimate the remaining lifespan and determine whether the battery is suitable for reuse or repurposing. This information also enables companies to offer informed performance guarantees, which are especially important given that second life batteries are competing with new batteries from established, larger manufacturers. Without access to manufacturers' battery management system (BMS), determining the SoH requires an expensive and time-consuming testing process.

The reuse and repurposing sectors would also benefit from increased access to identifying information about the battery type (i.e. chemistry, voltage, and rated capacity) and history. Repurposers must connect batteries of the same make and model in storage units, and transparent information about the battery history would alert anyone working on the battery to follow special safety protocol if the vehicle had been damaged or in an accident.

First-life battery design

The repurposing process can be done at the cell, module, or pack level. Both of which require removing the pack from the EV, and in the case the pack is broken down to the cell level, disassembling the LIB pack. The lack of standardization between OEMS complicates the secondary market because the disassembly and dismantling process is different, and in many cases, the repurposers can only use one type of battery in each of the second-life stationary storage applications. Since batteries are not designed to be disassembled by remanufacturers or repurposers, the process can be dangerous and lengthy. In many cases there are adhesives used that created added difficulty in steps that could be disassembled by a screw and bolt, if the battery was designed for disassembly.

Acquisition challenges

The current supply chain of used batteries presents a barrier to advancing the second-life industry. There is a near term lack of volume related to the nascency of the EV market in general; the quantity of EVs currently being retired is low compared to the amount that will retire in the next several decades. Furthermore, the supply of retired batteries will likely be dispersed between dealerships, auto dismantlers, insurance auctions, and scrap metal recycling facilities, complicating the reverse logistics process.

Opportunities and benefits

Environmental benefits

Harnessing the remaining usable capacity in retired electric vehicle batteries may displace demand for new battery products, which avoids the negative impacts associated with mining, refining, and manufacturing and reduces reliance on imported critical materials. Alternatively, deployment of repurposed batteries may expand the energy storage market, rather than simply displacing new battery production, in which case key environmental benefits may come from supporting grid goals and the renewable energy transition.

Incentivizing the purchase of reused batteries rather than favoring new products also promotes more sustainable behavior. Finally, there is an opportunity to reflect life cycle impacts and benefits in policy (i.e. by including them in policies like SGIP) to capture externalities in incentive programs.

Economic opportunities

A key economic benefit of reuse is the job creation that would accompany the development of a new industry, not just in the state but as part of a labor force that could spread across the country. Participants pointed out that the solar industry, where job creation helped fuel the industry, may provide a model.

Another economic benefit is the potential cost savings to the end-user of a repurposed battery system, who could realize the savings promised by new energy storage systems at a lower cost. More affordable energy storage also promotes equity by enabling households and communities to be more resilient in the face of natural disasters, for example by providing backup power during public safety power shutoff events.

Encourage transparency and coordination across the value chain

Participants identified an opportunity to set expectations and criteria about the traceability and capture of products before they are put onto the market, which would provide a positive example for other industries. Encouraging reuse and repurposing could also enable repairers to connect with OEMs, encouraging a feedback loop so OEMs know how to design for repair or repurposing, and design the market to avoid planned obsolescence. Finally, tracking product longevity and resale can be an incentive for brands to prove they are not planning for obsolescence

Recycling

Scope and definition of recycling

The recycling subcommittee was formed to identify options to address barriers and incentivize recycling that minimizes environmental and economic cost while maximizing material recovery. The scope covered includes material recovery via recycling process.

Summary

The recycling of electric vehicle batteries at the end-of-life (EoL) faces a number of barriers as well as opportunities and benefits that can be grouped into larger themes. For barriers these include the current regulations, economics, industry development within the United States, and lack of information and data. For opportunities and benefits these include reduced environmental and social impacts, economic opportunities and benefits, increased safety, and recycling industry growth. The following text outlines the barriers and opportunities in greater detail.

Barriers

Regulations

The regulatory environment within California, and at a national and international level, is a common barrier for the LIB recycling industry. Overall there is an unclear understanding of the regulations and a lack of alignment between the state and the U.S. EPA. California has a lengthy permitting process to establish a recycling facility within the state that likely deters industry. While DTSC has improved their processing to an average of two years, this is still a long and costly time for a business developer to wait. There is also added uncertainty of the permit being granted considering there has not been a hazardous waste recycling facility sited within California in over 8 years.

This type of regulatory uncertainty makes investment in recycling infrastructure risky and deters industry from development within California. This risk is exacerbated by an unguaranteed stream of retired LIBs due to a lack of consolidated take back, collection, or reverse logistics system within the state. While this report is California specific, it is important to note that at the national scale there is currently no regulatory alignment of strategies for recovering critical materials within the US, which has been an additional barrier to the recycling of LIBs. This may change in the near future due to the recent executive order (#$&%#), and it is unclear if CA is prepared to align with these strategies.

Economics

For recycling to proliferate without government intervention it must have strong economics resulting in the ability for recycled material to compete with virgin ore. Currently, recycling is considered uneconomical and the value of recovered material is uncertain due to the change of cathode chemistries and the value of material. The use of cobalt in the cathode chemistry has been reduced due to the high cost of ore, which in turn reduces the value of the recovered material. While there are a handful of industrial scale LiB recycling plants globally, the closest in geographical proximity is Retriev in British Columbia, although Li-Cycle has plans to begin construction of a new facility in New York and Arizona. Considering these developments, it is assumed these investors predict future positive economic gains, although the lack of industry data and actors makes it difficult to predict the economics of LiB recycling, and necessary steps the government can take to decrease costs or subsidize the process.

Another barrier to creating positive economics, as discussed in the regulation section, is a lack of guaranteed stream of EoL LIBs due to inadequate reverse logistics infrastructure. In addition, the responsible party for the cost of disposal of the EV at the EoL is currently the owner of the vehicle. This does not encourage recycling considering there is an additional cost to the recycling of the battery and no easy and accessible reverse logistics route with a set up collection point. Both of these barriers can result in the exporting of EVs or spent LIBs, therefore resulting in the loss of recoverable critical materials. This uncertain EoL pathway for EVs, along with the comparably lower volume of EVs reaching their EoL now than the amount that will occur in the coming decade, results in a cost of recycling per battery, and the inability to take advantage of more favorable economies of scale.

Industry development within the United States

The industry development within the U.S. is stunted by the lack of government investment through a stimulus or public - private partnerships. Due to the uncertain economics, this type of kick-start is needed to both improve the recycling technology and processes within the industry, create economies of scale, and produce industrial scale data for further research. Another batterier to the development of an industry within the U.S., is the lack of a LIB battery supply chain in North America that will purchase the recovered materials after recycling. While there is the manufacturing of cells within the U.S. (e.g. Panasonic for Tesla), the processes before the cell manufacturing and after recycling on the supply chain, such as cathode manufacturing, are not located within the nation. This loss of assets through exporting recovered materials to produce cathode materials could be detrimental to the goal of increasing energy security by recovering the critical materials cobalt, nickel, lithium, and manganese.

Lack of information or data

The lack of knowledge about the battery at its EoL is a barrier to recycling by resulting in increased costs and increased safety risk. For recycling to be most efficient, the cathode chemistry should be labelled, and disassemblers should have knowledge as to the safest way to remove the battery from the EV. The recycling process is less efficient and therefore results in higher costs due to the lack of standardization of design between manufacturers and the lack of design for the removal, disassembly, and recycling of the battery. An additional barrier to recycling is the lack of knowledge as to if the recovered materials can be a direct substitute for virgin ore in cathode and battery manufacturing. If recovered materials can be a direct substitute, there is a potential for material circularity and in increased economic value of recovered materials. This type of information should be gleamed from discussions with researchers and OEMS.

Opportunities

Reduced Environment & Social Impact

The recycling of LIBs will reduce the environmental footprint by replacing primary materials with the recovered materials. This in turn, conserves resources and maximizes the use of existing materials already extracted. This reduced ore extraction minimizes the environmental and social impact; The mining of cobalt results in human rights abuses which stem from both improper protective gear for workers and the use of child labor in the Democratic Republic of Congo. In addition, the mining of all these critical materials create health impacts on the local communities and strain them for resources, such as water. Locally, the recycling of LIBs will conserve landfill capacity and reduce the reliance on hazardous waste landfills. Proper management will also reduce the risk of fire or leaching of toxins that could occur if the battery is not stored or taken care of properly at their EoL.

Economic opportunities

The development of a recycling industry within the nation presents an opportunity for the creation of jobs that require a skilled labor force. In addition, there is the economic opportunity of reducing reliance on overseas materials, and the risk of supply disruption due to geopolitics. By recycling within the nation, the recovered materials can be used in the production of new batteries to support the clean energy transition, therefore reducing the vulnerability of the nation to price shocks. This national supply, along with increased economies of scale and technological improvements, has the potential to result in the decreased cost of batteries.

Recycling industry growth

As the recycling industry becomes more robust within the nation, it could potentially lead to the development of a national battery supply chain and an enhanced closed-loop model. A closed-loop LiB supply chain consists of the used batteries sent to recycling to recover the critical materials, which are then sent to manufacture cathodes, and the cathode is then sent to the battery manufacturers. Currently, there are no cathode manufacturers within the U.S., which would require the recovered materials to be shipped internationally, and thus losing the domestic supply and energy security provided by the recycling process. The development of recycling within the nation will provide a product locally that incentivizes the development of these intermediary industries to reside within the U.S.. In addition, increased recycling will inevitably lead to technological innovation within the industry that could result in higher recycling efficiency, thus minimizing residual waste, as well as economies of scale and economies of learning, that result in an economically sustainable industry for all parties involved.