Future of Lithium Ion Battery Standardization

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Market Battle for Lithium Ion Battery Standardization

The current infrastructure of recycling lithium-ion batteries from electric vehicles is very poor and could use much advancement. The present-day substandard process recycles less than 5% of all lithium-ion batteries globally (Wollacott 2021). In addition, a variety of pollutants such as lithium, nickel, cobalt, and others enter water sources or landfills when incorrectly recycled. Meanwhile, oftentimes during the collecting and recycling processes these lithium-ion batteries can go undetected in piles of garbage and get compressed in a truck, accidentally run over by a loader, or jostled around on conveyer belts in waste facilities (Varanasi 2022). According to an article from Dan Race from UNCTAD, the mining segment of lithium requires vast amounts of groundwater, an estimated 2 million liters of which to pump out brines from drilled wells all to create a single ton of lithium. This lithium mining accounts for 65% of the water usage in the Andean region which causes “groundwater depletion, soil contamination, and other forms of environmental degradation, forcing local communities to abandon their homes” (Race 2020). These sources portray the current methodologies for producing lithium-ion battery packs as creating much waste and contamination.

To combat the issues involved with lithium-ion battery recycling and the potential benefits of standardizing the recycling processes, my research will focus primarily on the market battle standardization of lithium-ion battery packs in electric vehicles. Specifically, I will seek answers to the following: Who are the most active stakeholders in developing lithium-ion battery standardization? Who are the most active stakeholders against lithium-ion battery standardization? From these two groups of stakeholders, what analysis can be done on the

practices being performed? Specifically, I will research the exact methods stakeholders push for in standardization and analyze the feasibility of implementation of said methods into production. I will also analyze the points against standardization by acknowledging the eagerness for innovation and market competition of the electric vehicle world.

Firstly, I will discuss the groups which believe the current infrastructure surrounding lithium ion battery recycling is subpar and the enhancement in standardizing batteries would benefit the environment.

An author who has extensively researched standardization methods is Lisa Gaines from the Institute for Natural Resources. According to a paper written by Gaines, the primary stakeholders driving standardization of lithium-ion batteries "[are] being addressed in the United States by the Society of Automotive Engineers and in Europe by EUROBAT. Both groups have active working groups attempting to better define and find solutions to the problems of cross-contamination of battery types in recycling streams" (Gaines 2014). The best practices for standardization from EUROBAT and the Society of Automotive Engineers in standardization are "label[ing] battery components by means of bar codes, RFID chips, or delegated paint color or type (e.g., visible under black light)." Gaines argues these standards would allow recyclers to more easily separate lithium-ion batteries from acid-based batteries and extract lithium-ion components in a more straightforward manner. The more streamlined process can allow for a higher percentage of components to be recycled, as well as lower the price of recycling as the recycling method is now simplified.

Another more technical method of standardizing lithium-ion batteries comes from the Journal of Cleaner Production. This source looks at the adoption of "ISO 15118, a communication standard for V2G capable EV charging in four countries" (Kester, Noel, Lin, Rubens, Sovacool 2018). This paper explains the bidirectional electricity flows and the ability for electricity grids to utilize EV batteries as a result of a single standard of vehicle to grid (V2G) mobility. The study's conclusion states that ISO 15118 is a crossover between technical and political achievements, as the "interoperability between two industries and a subsequent potential scalability of EVs that is required for a further transition of our transport system away from fossil fuels". Specifically, a technical and political crossover is established between the bidirectional electricity technology from lithium-ion batteries to power grids, and the new source of electricity sent to public infrastructure created by local and federal governments. The partnership between governments and lithium-ion battery pack manufacturers could begin the start of an important regulatory relationship on lithium-ion battery packs. This very early study on EV standardization aims to push back energy from electric vehicles to the power grid to be used in homes, offices, and the general power supply of the world. The direct redirection of power from this paper allows energy suppliers to save vast amounts of energy as well as recycle and reuse lithium-ion battery parts. This EV standardization will act as a benchmark for standards and technological developments to come.

Another extremely present organization in lithium-ion battery standardization is UL, formerly known as Underwriters Laboratories. UL frequently publishes standards for different electric appliances and a plethora of battery types. Their most applicable publication towards

lithium-ion batteries and this topic of standardization being “UL 1642: Lithium Batteries”. The entire publication has vast amounts of standards and tests to be performed on lithium batteries in order to ensure both their validity and reliability. One specific standard introduced to ensure validity and reliability is, “User-replaceable lithium cells or batteries are to be tested...complying with the Crush Test” (Prusko Section 5.2, 1999). The crush test from author Prusko would test lithium-ion batteries after they are at the end of production, and record how each battery reacts to being crushed. The results would record whether the identically produced batteries react the same under pressure, as well as how different manufactured batteries compare to being crushed. While this article is relatively older it shows that lithium battery reuse standardization has been around for over two decades and can be expanded into the designs of larger EV battery packs.

Finally, another proponent for lithium-ion battery standardization are the researchers from BBC news. According to the article from Allison Hirschlag “…in about 2025, when millions of EV batteries reach the end of their initial life cycles, a streamlined recycling process will look much more appealing to economies the world over. So perhaps, by the time EVs become the predominant form of transport, there will be a good chance their batteries will be gearing up for a second life” (Hirschlag 2022). Hirschlag’s argument for standardization lies in the fact that many lithium-ion batteries are reaching the end of their life within the next decade, thus having the infrastructure in place to repurpose them would be greatly beneficial to give the once used batteries a second life. The recycling infrastructure for EV battery packs would be create a bridge between private and governing bodies as both would benefit from this infrastructure. Manufacturers gain as the cost for batteries would be lower, while governing

bodies gain since there would be more reuse in the economy saving the production of more pollution.

Now I will discuss the counterarguments towards standardization of lithium ion Electric Vehicle batteries and the arguments these stakeholders present.

A large prospect of standardizing EV batteries would be the ability to re-use batteries from other manufacturers and give each battery a second or multiple lives. The issue with this, according to an article by John Voelcker from Green Car Reports is that, “incorporating a battery pack developed by someone else would impose significant constraints on how they could arrange their components, crash structures, and the like“ (Voelcker 2014). Voelcker argues the risks of standardizing battery packs and the inability of different components to be configured with other manufacturers without a complete redesign of the EVs. Aside from the alarming aspect of danger being introduced into EVs by uniforming electric vehicle batteries, a total redesign of electric wiring, body work, and crash tests would need to be done costing each manufacturer hundreds of millions of dollars. The persevering message from this source is the fact that the biggest stakeholders posing as barriers to standardizing battery packs are the manufacturers themselves since they would be forced to invest hundreds of millions of dollars in redesigning the entire vehicle to conform to standardized batteries.

Another author which showcases skepticisms on standardization is Lawrence Ulrich from IEEE. The IEEE article largely discusses progressions in battery swapping and its dependency on EV battery standardization. The quote from Ulrich “Ultimately, competition and capitalism itself

spells doom for battery swaps. Commonized vehicles and battery packs would require every major automaker to tear up existing and future product plans and start from scratch" (Ulrich 2021). This excerpt explains the general sentiment against battery standardization in that the standardization would cause a step back in the past decades of lithium-ion battery technology advancement and bring a halt to the current technological soaring in the EV industry. There also exist companies in China and other Asian countries such as Nio who swap out used batteries for fully charged batteries in aims to increase range of driving in shorter amounts of time. This is a relatively early example of reusing EV batteries and has proven successful in Asian countries while avoiding standardizing or uniforming the battery packs however the difficulties in this battery swapping lie in the fact that only certain car companies can partake in the battery swapping since not all battery packs are compliant with the specific requirements for the charging and swapping stations.

While standardization of the battery packs would lead to many environmental benefits in lithium-ion recycling, the fact is that too much standardization is unwelcomed in any industry as it stifles innovation and can lead to all products in the industry being indistinguishable. According to Roger Brereton from Pailton Engineering, "[EV] is not yet a mature technology and progress is being driven by competition" (Brereton 2020). Brereton's argument is that there are still large strides in innovation to be done in electric vehicle technology with the first wave of electric vehicles hitting the market in the late 2000's, albeit not being able to match their gas-powered counterparts. A decade and a half later, the technology has come a long way, however counter criticisms to battery standardization still arise from the EV companies

themselves as they have spent years designing their batteries to perfection. The likes of Tesla, GM, and other manufacturers are unlikely to hand out their latest electric vehicle research and advancements to each other. Brereton predicts that the industry needs to "meet half way to provide enough flexibility and innovation to keep [electric] vehicles competitive, and the right level of standardization to keep costs feasible." Instead of uniforming all electric vehicle batteries between companies causing a major redesign in all car companies across the world, Brereton's half way point would be something along the lines of Gaines' idea of labeling battery packs to aid in recycling individual parts.

Through the use of the Risks and Standards Framework, I will examine the market battle standardization for lithium-ion EV batteries. This framework helps me to examine which actors are aiming for the minimization of waste and standardization of lithium-ion batteries, how the waste minimization technology is valid, and the counterclaims involved with the standardization.

First, we will analyze the stakeholders and their arguments who are against standardization. As discussed in the Roger Brereton article, too much standardization stifles innovation and is unwelcomed in any industry for advancing progress. This is a valid argument as companies such as Tesla, Ford, and GM spend billions of dollars in their research and development sectors in aims to increase the range and capabilities of EV batteries. Standardizing batteries across all companies would limit the progress and the overall product available to consumers would be dramatically exacerbated. Another source from John Voelcker discusses the intricacies of incorporating different automobile elements which are made by different manufacturers. Standardizing a battery across the industry can lead to safety concerns which is

very undesirable and can lead to compromises in car parts such as the crash structures, airbags, electronic wiring, as well as self-driving capabilities since these are all largely dependent on the batteries being custom designed towards the specifications of the vehicle.

Finally, we will analyze the stakeholders and their arguments who are pushing for standardization of EV batteries. It is clear that mining for the materials used in lithium-ion batteries are costly and deplete resources from the surrounding areas (Race 2020). Therefore, the ability to recycle the finished batteries would save on the initial phase of extracting the raw materials from the earth. Circling back to the Gaines technical methodologies of standardizing lithium-ion batteries, some of the relatively simple standardizations to implement onto the lithium-ion batteries are labeling components with bar codes, RFID chips or paint colors to give recycling plants ease in separating and extracting components (Gaines 2014). These methods are easy to implement and would not greatly affect the design of the batteries, which would avoid the issues like safety concerns or innovation stifling as a result of all batteries being uniform in design. This method of standardizing is likely the easiest as it standardizes by adding simple components rather than causing total redesigns of the battery as well as letting companies continue with advancing EV technology. Another method of standardization discussed in my sources is from the Underwriters Laboratories (UL), where they created performance tests to ensure validity and reliability. One such example is known as the crush test where a battery must be able to withstand certain force exerted on it. This relatively early example of standardization is another example of how manufacturers can standardize their batteries without causing manufacturers to completely uniform their battery packs across the market.

After viewing both the arguments for standardization of lithium-ion EV batteries as well as arguments against, I have concluded that standardization is the best option for the future of greener vehicles. Standardization is needed to make electric vehicles truly a better form of travel in order to reduce the waste produced by extending the lives of these batteries. While I advocate for standardization, I do not mean a completely uniform battery to be used in all electric vehicles as this would wipe out the automotive market drive to improve their product. Similar to the standards discussed in UL and the Gaines article, I believe standards which are simple to incorporate and expedite the recycling process will be helpful in the future.

Realistically, a battery which is the same for all automotive companies would never be agreed upon by company executives. Standardizations that would have a higher percentage of being implemented and having an effect on reducing waste would be similar to the tests to ensure validity and reliability, as well as markers on the batteries to easily differentiate the battery components when recycling the batteries. This obviously means that the newly standardized batteries would not be able to be swapped between vehicles after the first use, however it would still improve upon the current recycling process. In addition, it is a viable and realistic move forward toward the ever-growing industry of electric vehicles. These methods of standardizations would most follow the "equilibrium" point between no standardization at all and totally uniform battery packs discussed by Roger Brereton in order to "provide enough flexibility and innovation to keep [electric] vehicles competitive, and the right level of standardization to keep costs feasible" (Grereton 2020). Some of the next steps in expanding on standardization are researching more technical standardization methods that can be implemented which won't cause

a total redesign of batteries, as well as finding more stakeholders who are against standardizing and the validity in those arguments.

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