

# Lithium-ion Car Battery Recycling Advisory Group Meeting Minutes May 27, 2020

## 1. Call to Order, Roll Call, and Establishment of Quorum—Caroline Godkin

- Roll Call
  - Present:
    - Caroline Godkin
    - Teresa Bui
    - Mohammed Omer
    - Terry Adams
    - Dan Bowerson
    - Mark Caffarey
    - Perry Gottesfeld
    - Steve Henderson
    - George Kerchner
    - Bernie Kotlier
    - Jennifer Krill
    - Nick Lapis
    - Allison Linder
    - Geoff Niswander
    - Lou Ramondetta
    - Alissa Reinhardt
    - Todd Coy
  - Quorum is established
- What has changed since last meeting in January
  - Our lives are in chaos and thank you to everyone for their ongoing commitment to this work
  - Planned climate investments have been sidelined in light of pandemic budget crisis; state is looking at 54 billion dollar deficit
  - Director of Cal EPA has been named to recovery committee
  - Changes to Open Meeting Act; governor waived key provisions. All meetings for 2020 are planned to be offline
- Today will involve a deeper dive into second life, encouraged committee to consider policy recommendations

## 2. Interim Updates – Mohammed Omer

- Thanks to everyone
- Dirk Spiers is unable to attend
- Meeting minutes from November and January need to be formally approved
  - November minutes formally approved
  - January minutes formally approved
- Jonathan Weisman is no longer on the committee
  - Question from Dan: will someone from Tesla replace his seat?
  - Unclear, Caroline is working with Secretary + Governor on following protocol for replacement
- Bernie Kotler, big battery update:
  - Visited Big Battery in Southern California
  - Big Battery is buying significant quantities of complete EV packs for testing, dismantling, repurposing
  - Significant impediment = meeting lab certification
    - Must test and list each battery, which creates a cost barrier
  - Todd: UN 38.3 are mandated by law by DOT, the standards are there for a reason. UL standards are voluntary. There is a cost but that is the industry.
  - Bernie: Yes, not advocating for relaxing safety standards, but we should be cognizant of how they will interact with industry
- Geoff: Attended CEC's lithium recovery initiative at Stanford
  - Discussion of starting lithium mining operations in Salton Sea area, extract lithium from brine resulting from geothermal operations
- Todd: CEC also announced second life grant program

## 3. Presentation on Testing, Reuse and Second-Life Applications

Dr. Hanjiro Ambrose, Union of Concerned Scientists & UC Davis Institute of Transportation Studies

- Hanjiro: We will hear from one of the CEC winners today.
- Outline
  - Market potential, technical potential, second-life applications; what amount of batteries will be coming off the road?
  - Ryan Barr will talk about RePurpose Energy
  - Barriers and Policy
- Potential benefits (key perceived benefits)
  - Mitigate environmental impacts of battery manufacturing
    - Decrease normalized impacts by extending lifetime
  - Reduce cost of new EV batteries
    - Added value could mean realized savings that could be passed through to first owner

- Enabled increased use of renewables
  - Increased renewable penetration requires energy storage, second-life could play a part
- Second-life market
  - Supply
    - Just looking at existing sales, retirements that will be coming off the road in next 5-10 years will be ~5x the current storage demand
  - Demand
    - Increased demand for stationary storage in California and other states, both utility + behind-the-meter. Behind the meter is for a home, commercial building, or fleet (for example amazon warehouse)
  - Potentially a match made in heaven, but a lot of barriers
- Technical potential
  - Battery lifetime is a function of degradation
  - Current EV batteries are expected to be able to deliver >1000 cycles up to 80% of initial capacity
    - Manifests as decreased range
    - “Power fade” → lower voltage, higher to deliver higher rates of power (i.e. accelerating a vehicle)
      - This is what makes them suitable for reuse, much of the stored energy will be accessible at a lower power application. They can have a longer life in a second life application where the power rate can be lower.
  - Degradation pathways: temperature, cycles, time
    - If vehicles are idle most of the time, cycling will have less of an impact and calendar degradation will be a key determinant, meaning second-life availability may be more predictable
  - Greater capacity + performance of new batteries increases second-life potential; for example, 2012 Leafs degraded quickly and have low kWh for second life storage, but modern vehicles will have much higher capacity
- Repurposing an EV battery
  - Testing battery
    - Testing is important because data being passed to repurposer is limited
    - Repurposer needs to understand battery’s state of health (SOH)
    - Types of testing
      - Visual inspection for physical damage
      - Electrical testing (shorts, over/under charging)
  - Removing battery from vehicle
    - Different transportation considerations for batteries inside vs. outside vehicles; if battery is shipped as a waste product it’s subject to hazardous waste restrictions

- Reconfiguring battery for second-life application/ Refurbishing
  - Entire packs can be repurposed, or batteries can be dismantled to module-level and reconfigured
  - Systems also may need to be equipped with new battery charge management system
- Costs
  - Even with repurposing costs, still adds value; residual value is about a third of original value after repurposing, according to graph based on NREL repurposing calculator

#### Ryan Barr, COO, RePurpose Energy

- Increased solar shifting peak energy hours and making solar + storage more profitable than solar alone
- Global battery demand primarily driven by electric vehicles
- Second-life batteries avoid environmental impacts of new battery production
- RePurpose has a commercial-scale demonstration at Mondavi Institute
  - Reduced facility's evening use by ~40%
- Next project will install ~75 used Nissan Leaf batteries at grocery store, demonstrating cost savings, measuring + mitigating degradation rates (5x size of current demonstration). Made possible by CEC grant.
- Policy suggestions:
  - Ensure eligibility for key incentives to enable competition with new batteries (e.g. SGIP)
  - Encourage solutions with low production emissions
  - Centralize or increase oversight of battery collection and disposal

#### Back to Hanjiro

- Growing number of pilot and demonstration projects
- QUESTION: Is RePurpose nonprofit or private company? Where does funding come from?
  - Ryan: private company, funding from grant awards and private equity
- Economics of energy storage
  - Stacked value== batteries serve multiple uses; e.g. backup power, demand response, deferred infrastructure upgrades
  - Some value streams are abstract and more difficult to capture, like backup power
- Key issues
  - Data (progress being made)
  - Logistics
  - Reliability + performance
    - Establishing standards is important

- Competition
  - Falling price of new batteries has been a challenge; second-life should be able to offer a price advantage as new batteries approach a cost floor
- Recommendations
  - Continue to encourage more demonstration projects
  - Reform regulations that prevent second-life from accessing specific markets
  - Offer tax credits, rebates, and incentives
  - Make data available and adopt data standards
  - Develop technical performance standards
  - Fund further research

## QUESTIONS

- Jennifer: Clarification on Ryan's reported GHG impacts for battery productions; it's quite a large, what steps are considered?
  - Hanjiro: Focuses on the cradle to gate. This shows the emissions from raw material extraction, transportation. There is a wide range and it is a moving target. The more recent from Argonne lab show 65 kg/kWh to 100 kg/kWh based on localized production. Producing batteries is intensive and it is not always clear that storage reduces ghg benefits.
- Perry: What were the assumptions behind the claim that benefits for new batteries are only realized after 15 years?
  - Ryan: This refers to new batteries for stationary storage
- George: ESS are standardized, mass-produced based on single module design. For second-life products, are they able to use different modules in a single ESS?
  - Ryan: company needs to be strategic about which batteries they use; new testing process is required for different battery types
  - Trying to make an energy storage system from different modules ("form factors") is difficult if not impossible. This was a challenge when EVs started taking off ~15 years ago. There is a lot of variability among the LIB industry which creates a challenge for companies looking to use them
- Mark: Any idea how long second life batteries might last? What happens to pack or module when they reach end of second life?
  - Hanjiro: Between 5-10 years depending on application after 8-12 years in an EV are typical literature estimates
  - They should be recycled after reuse; reuse is not an end-of-life strategy. Question of who recycles and owns the batteries after second life is an important consideration

- Dan: Battery prices are falling and expected to continue coming down; is there a possibility that new batteries will be cost-competitive in the future?
  - Hanjiro: that's been a concern but he expects that there will be a floor for new battery costs; we are reaching a point where material costs are a significant portion of battery costs so the likelihood they will fall another order of magnitude is low
  
- Allison: What about opportunity to beneficially use/charge EVs while they're still in use on the road?
  - Clarification that RePurpose's demonstration is not using batteries that are still in use in EVs
  - Charging EVs during cleaner/off-peak hours can realize environmental benefits, and bi-directional charging is also a potential opportunity
  - Could that impact the demand for second-life batteries?
    - High demand for storage means we will be able to use all models
  
- Question from Ben Wender from CEC:
  - What are the barriers/limits to automating testing and inspection?
  - Ryan: RePurpose is taking steps to automate in order to shorten total test time
    - Will not eliminate humans from the process because modules need to be inspected for physical damage
  
- Perry: Is this graphic showing the best-case scenario and does this include transportation costs? Are transportation costs significant?
  - Hanjiro: Repurposing costs displayed are on the relatively low end and assume a low failure rate and high volume
  
- Terry: Question about removal from vehicle; was this cost factored in?
  - Hanjiro: Not included, that would be reflected in the purchasing cost. Second life batteries available generally come from OEMs. We do not have a good understanding on the costs of this process.
  - Electric vehicles at Terry's company are given a negative value because of the expense of removing battery and hauling from facility

#### **4. Presentation on Battery Lifecycle Tracking**

Lauren Roman, Business Development for Metals and Minerals Ecosystem at Everledger

- Background on Everledger: company is 5 years old, located in London. Employees are industry experts, not only developers. They are involved in developing a Battery Passport to track minerals coming out of the ground to their final EOL location.

- Metals and minerals ecosystem solutions
  - Focuses on LIB and electronics lifecycle management
  - NAATBatt → Researching value of EVC lifecycle traceability platform
  - Global Battery Alliance → Developing global Battery Passport
  - Responsible Batteries Working Group
- Everledger platform
  - Combines blockchain with Auto ID, other identification technology
    - + AI, Internet of Things, Intelligent Labelling, Nanotech
  - Enables producers to validate compliance with certain standards, proving sustainability claims, establish trust with consumers, transparency
- Industry examples
  - Diamonds and gemstones; conflict labor, human trafficking, child labor. Working to prevent this and assure consumers that they are buying products that do not support that sort of activities
  - Apparel, luxury goods, wine: Ensure that products are legit if you are into that
  - Insurance: Prevent fraudulent claims
  - Electronics: LIBs and portable battery products
- So what is Blockchain anyway?
  - Data is shared with multiple computers simultaneously
  - Additional blocks can be added to correct errors, but original data cannot be changed
- Battery traceability
  - Starts at manufacturer; traceable ID needs to be placed on battery pack
- Relevant projects and key partners
  - Battery Passport, Future Battery Industries Australia,
  - New Zealand Battery Industry Group → producer responsibility scheme for NZ
  - DOE Battery Recycling Prize
- Ecosystem stakeholders
  - Production, collection, life cycle extension, resource recovery
  - Blockchain allows data to be shared across all stakeholders; production data doesn't get lost by the time it gets to recyclers
- Data visibility challenge
  - Safety, repair/disassembly instructions, battery history (service, repairs, accidents), accessibility of BMS data, title transfer to repurposer, have battery parts been authentic? Management of EOL batteries, accounting of critical minerals
- Production risks, challenges, opportunities
  - Producer responsibility schemes, counterfeit batteries, warranty authentication
  - Low EV resale values (lack of consumer confidence, current incentive structures)

- Safety
- Liability for subsequent uses
  - Blockchain validation of title transfer can protect OEM
- Recycled content validation
- Secure metal supplies
- Collection risks and challenges
  - Shipping and storage, under warranty?
  - Safety issues
- Life Cycle extension
  - Unknown chemistry
  - Can battery be repaired/reused or has it been physically damaged? Is the state of batteries suitable for repurposing?
    - If batteries are not suitable for repurposing, dealing with packaging and shipping of faulty batteries is a huge issue
- Resource recovery challenges:
  - Tracking & recording critical metal content, protecting OEM brand
- Traceability pilot
  - DOE
  - Retrieval
  - Ford
  - GBA
- Demonstration
  - NFC Tag. A recycler could hold their phone near battery to scan it, and will be taken to a page containing a “battery document hub,” battery chemistry/metal content, component diagram, lifecycle management
- Portable LIB recycling
  - Give portable LIBs a digital identity
  - Partnered with Call 2 Recycle
  - Currently in Phase II; developing prototype of consumer-facing app
  - Phase III: conduct consumer engagement research study to test app

## QUESTIONS

- Jennifer Krill: Are you familiar with the Initiative for Responsible Mining Assurance? Are there steps we can take to marry best practices for mining standards with best practices in traceability?
  - No and she looks forward to connecting
- Lou Ramondetta: Good concept; what cost does this add to a typical battery? Have you talked to other battery manufacturers to find out if they are willing to put this on batteries?
  - Lauren: Working with all stakeholders listed on slides. Currently working on identifying costs, which are “not that high,” and on defining the *value*; how much could a repurposer or recycler save by having this information?

What is the value of brand integrity for manufacturers, better safety control?

- Cost of traceability in China estimated to add 4% to value of battery
- Perry: What is the cost per wine bottle, as an example?
  - Cost per tag is in cents, cost per wine bottle??
- Teresa: Is the traceability at commercial or pilot stage?
  - Currently at pilot stage, they'll need to have proof-of-concept for DOE in October and if they move onto Phase III they'll do a full-scale pilot
  - How could recipients of batteries get information without doing individual checks?
    - They just have to do it individually, that's how it works now
- Mohammed: Who will be inputting the data? Will stakeholders be trained on how to upload data?
  - Garages (for example) will benefit from having information. Conditional access to the system requiring users to upload their own data could be an incentive to participating
- George: What is the cost associated with transporting batteries?
  - They are launching a survey from recyclers to estimate cost
  - One committee member is working on this and expects to have numbers by July

10 MINUTE BREAK

## 5. Discussion

- Caroline: Going alphabetically for each person to offer their thoughts and policy recommendations
- Terry Adams
  - From autodismantling perspective...
    - Are batteries removed hazardous or universal waste?
    - How to manage cost? As manufacturers reduce value of materials, there's not enough value to cover waste management costs
    - Regulatory and safety considerations
    - Providing training and education/information will be important
  - Question from Caroline: What are you doing with batteries you are seeing now? Are they all going to recycling or are you sending some of them to repurposers?
    - Cost of removing batteries is a disincentive for buying used Priuses
    - Regulations that support logistics of removing batteries and getting them into supply chain for second life without running into hazardous waste issues would be helpful
- Dan Bowerson
  - To be responsible for EOL, we need the whole value chain involved

- Any policy put forth needs to be cognizant of the nascent industry; adding cost today could negatively impact an immature market. Need to be open-minded of this as we discuss how to pay for policies
- Clear liability for secondary use will be critical; education component is also necessary (educating public about opportunities of EOL batteries)
- Policy should still be fluid given evolving nature of battery tech
- Question from Caroline: Where does liability fall now?
  - Doesn't know for sure, there is probably a gap now
  - OEMs are not responsible once battery comes out of the vehicle as far as he knows
- Mark: skipped, no response
- Todd:
  - Jumping ahead to policy; it would be very early to start looking at policy recommendations. As a group we need to gather additional information, facts, ideas about where market is going before we discuss policy
  - There may be a schism between industry vs. government; government will be pro-regulation,
  - There is legislation winding through the capital right now, we should take into account the potential impact of that
- Perry:
  - Not completely sold on viability of reuse model based on economics; might be a niche industry but remains to be seen. Worth exploring requirements in China; consistent international standard would be useful. This will ultimately be a question of cost and we need to know more about the viability going forward.
- Steve:
  - Dan did a good job of explaining auto perspective. Presentation by Everledger was particularly interesting; issue of batteries disappearing after exiting warranty program will be "one of the thornier ones." We welcome the use of technology to keep track of batteries.
- George:
  - Secondary use is a young industry, niche market; EV industry is also in the early stages
  - Important not to prematurely establish policy recommendations that will stunt the growth of an industry that California wants to encourage
    - California has a history of overregulating industries and we want to avoid that
  - Discussion of batteries as universal vs. hazardous waste; that's up to generator
  - California is the only state in the country that considers alkaline battery to be hazardous waste. OEMs want to see industry grow and there is a lot of concern about seeing industry be overregulated. Policy recommendations shouldn't inhibit growth; hazardous waste classification inhibits growth,

and providing relief at EOL for batteries that stay within California would encourage growth

- Caroline: Any examples?
  - In Europe, LIBs are not considered hazardous waste in most countries which provides relief from shipping burdens \*\*
    - Batteries containing cadmium, mercury, lead are classified as hazardous, others aren't
  - Europe also has reduced regulatory scheme compared to LIBs
- Perry: they also have a mandated takeback scheme in Europe
- Bernie:
  - Agrees with Todd about earliness in process to be talking about policy recommendations
  - Represents electrical contractors; more supportive of regulations, while electrical workers want protection.
  - Extended producer regulations requiring collection is a critical piece
  - California isn't overregulated, we still experience pollution and we should be more concerned with protecting the health and welfare of Californians
- Jennifer:
  - Looking at existing frameworks for other materials in California + batteries in other jurisdictions would be valuable
  - California should continue to set a high bar for environmental leadership in this space
- Nick:
  - Appreciates that we started with reuse
  - If nothing else, we should aim to have clear guidance for how to treat batteries inside and outside cars
  - Block chain tracking is fascinating from the perspective of calculating accurate recycling rates and differentiating between different manufacturers. This type of granular tracking can help achieve greater targets
- Allison:
  - Thinking through different uses in different markets for second life
  - Case for heavy duty vs. passenger vehicles; heavy duty battery wouldn't need to change ownership to be repurposed
- Geoff:
  - Clarifying hazardous vs. universal waste; universal waste is hazardous waste that is common in the waste stream and allowed special exemptions, including batteries for California
  - Size of EV batteries makes them a unique challenge
    - Transportation is more costly
  - Presentations emphasize that we are in a unique position to make sure "these don't end up in the trash"

- PSPS will continue for the foreseeable future, so if they can be reused to support the grid in fragile, vulnerable conditions, action from this committee should at least encourage the exploration of that
- Caroline: suggested detailed discussion with experts from DTSC
- Lou:
  - Still struggling with value proposition/business model for second life. A lot of secondary markets are in infant stages and will take time to develop, so you still fall back to recycling and if there is an economic model. A lot of challenges from first meeting are still outstanding.
- Teresa
  - Need a deeper dive of how to lower costs and how can we collaborate with existing programs to allow reuse of batteries
- Mohammed
  - A lack of clarity will be more destructive than under- or overregulation
  - We do still need more information before we make policy but a general framework of ideas:
    - Clarity of regulation
    - EV industry is new so we don't want to write legislation to address issues we have today, we want to think 5-10 years out, learning from past mistakes
    - Tracking is key
- Caroline
  - We are trying to start to think in the mindset of policy recommendations, but we do still have a lot of work to do

#### Mohammed

- Looking ahead:
  - Next meeting scheduled for July 13, subject to change now that everything is remote
    - Topic will be material recovery from recycling
  - October meeting will be about logistics and infrastructure
  - 2021 will shift more towards policy recommendations, 4 meetings are anticipated
  - Goal is to have complete set of policy recommendations by 2022
- Wrap-up:
  - Summary of meeting:
    - Introductions/established quorum/approved former meeting minutes
    - Updates
    - Presentations
    - Break
    - Discussion

Caroline

- Thanks!