MUNICIPALITIES COULD PROVIDE VALUABLE SECOND-LIFE USES OF ELECTRIC VEHICLE LI-ION BATTERIES WHILE LEGISLATORS AND MANUFACTURERS REFINE SAFE RECYCLING AND DISPOSAL PRACTICES

Heather D. Stewart[*]

I. INTRODUCTION

The effects of climate change are felt all over the world and instead of standing by idly, local communities are taking powerful steps to transform their impact on the globe through decarbonization efforts. Decarbonization focuses on reducing ten key industry sectors that account for 80% of the world's carbon emissions.[1] Additionally, local communities are powerhouses of change capable of addressing each sector decarbonization focuses on in the fight against global climate change.[2] Although climate change is a worldwide concern requiring international cooperation, in the United States, state and local governments should not be overlooked as key entities to implement immediate practices to reduce carbon emissions and attain carbon neutrality.[3]

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[*] Heather D. Stewart, Esq., Class of 2022, Barry University – Dwayne O'Andreas School of Law. B.S. Environmental Science, Minor Geography, Stetson University 2008.

[1] David G. Victor, *Deep Decarbonization: A Realistic Way Forward on Climate Change*, YALE ENVIRONMENT 360 (Jan. 28, 2020), https://e360.yale.edu/features/deep-decarbonization-a-realistic-way-forward-on-climate-change [https://perma.cc/8ZCE-XB8P] (last visited Dec.12, 2020).

[2] Press Release, Buddy Dyer, Orlando Mayor Buddy Dyer Joins International & National Campaigns, Reaffirming the City of Orlando's Goal of Using Clean Energy and Reduce Greenhouse Gas Emissions (May 31, 2017), http://www.cityoforlando.net/news/2017/05/orlando-mayor-buddy-dyer-joins-international-national-campaigns-reaffirming-the-city-of-orlandos-goal-of-using-clean-energy-and-reduce-greenhouse-gas-emissions/ [https://perma.cc/JWJ9-PXNP] (last visited Dec. 12, 2020).

[3] VICTOR, *supra* note 1.

Scientists generally agree that a suite of greenhouse gases (GHGs) dominated by water vapor, carbon dioxide (CO_2), methane, nitrous oxide, and chlorofluorocarbons are the gases disrupting climate systems.[4] The most prevalent of these gases that force climate change is CO_2.[5] The build-up of GHGs in the atmosphere traps the reradiated heat of the planet that would normally escape back into space thereby creating a greenhouse-like effect.[6] The trapped heat is a potent energy that impacts land and ocean temperatures, which in turn disrupt weather patterns and precipitation, storm frequencies, and storm intensities, thereby creating climate changes.[7] Climate changes have direct impacts on land through increasing desertification of dry lands, increasing degradation of arable lands, river deltas, and plains, and increasing sea levels near coastlines and low-lying areas.[8] The more GHGs that are trapped, the more intense the effects on our planet.[9] Once trapped, the gasses do not dissipate easily, so finding effective methods to reduce the volume of these GHGs emitted in the first place is imperative.[10]

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[4] National Aeronautics and Space Administration, *The Causes of Climate Change*, NASA's GLOBAL CLIMATE CHANGE VITAL SIGNS OF THE PLANET, https://climate.nasa.gov/causes/ [https://perma.cc/2LL5-FTDG] (last visited on Feb. 7, 2021).

[5] *Id.*

[6] *Id.*

[7] Caroline Gramling, *Once Hurricanes Make Landfall, They're Lingering Longer and Staying Stronger,* SCIENCENEWS (Nov. 11, 2020), https://www.sciencenews.org/article/climate-hurricanes-landfall-lingering-longer-staying-stronger [https://perma.cc/QSR9-XFC5] (last visited Feb. 7, 2021).

[8] Jia, G. et al., Climate Change and Land: an IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems, Intergovernmental Panel on Climate Change, Ch. 5 140 (2019), https://www.ipcc.ch/site/assets/uploads/sites/4/2020/08/05_Chapter-2-V3.pdf [https://perma.cc/L8Q3-DCMH] (last visited Feb. 7, 2021).

[9] *Id.*

[10] *Id.*

In the U.S., the Environmental Protection Agency (EPA) published its most recent multidecade report attributing 81% of the GHGs emitted in the U.S. to CO_2.[11] Additionally, emissions from internal combustion engines (ICE) fueled by fossil fuels and used in transportation are the largest direct contributor accounting for 28% of the total amount of CO_2.[12] Electricity production is the next largest contributor providing 27% of the US's CO_2 emissions when electricity production comes primarily from burning fossil fuels.[13]

Efforts to reduce or reverse CO_2 emissions is termed decarbonization, which is accomplished when economic systems convert to employ sustainability practices that reduce and compensate for the emissions of CO_2.[14] The long-term goal is to create a CO_2 free global economy.[15] Decarbonization focuses on industry sectors to see how to decarbonize global power sources.[16] Practices, such as switching energy sources from fossil fuels to wind or solar renewables through rational economic behaviors, can achieve as much as 50–60% decarbonization at a reasonably low cost.[17] Furthermore, creatively addressing both the transportation and the electricity generation sectors promotes greater positive results at less cost.

Globally, the electric vehicles (EV) market is expanding fueled by government policy and regulation aimed at reducing the

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[11] United States Environmental Protection Agency (U.S. EPA), *Inventory of U.S. Greenhouse Gas Emissions and Sinks*, GREENHOUSE GAS EMISSIONS, https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks [https://perma.cc/LBH7-A6AU] (last visited Feb. 7, 2021).
[12] *Id.*
[13] *Id.*
[14] Volkswagen, *Decarbonization – What is It?*, VOLKSWAGENAG.COM, https://www.volkswagenag.com/en/news/stories/2019/03/decarbonization-what-is-it.html# [https://perma.cc/XX2H-RQFM] (last visited Feb. 7, 2021).
[15] *Id.*
[16] Jason Finkelstein, David Frankel, and Jesse Noffsinger, *How to Decarbonize Global Power Systems*, MCKINSEY & COMPANY: ELECTRIC POWER & NATURAL GAS (May 19, 2020), https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/how-to-decarbonize-global-power-SYSTEMS [https://perma.cc/64Y8-SJ83] (last viewed Feb. 7, 2021).
[17] *Id.*

dependency on fossil fuels and curbing GHG emissions.[18] EVs produce zero emissions while the vehicles operate, however, EVs are not zero emission from a cradle-to-grave perspective.[19] The production of EVs contributes, on average, twice as much to global warming potential and uses double the amount of energy as the production of ICEs primarily due to its battery.[20] Additionally, EVs are not GHG emission-free during charging cycles unless a renewable energy technology provides the electricity to charge the vehicle.[21] However, according to Frank Mühlon, Managing Director for a globally renowned EV charging infrastructure corporation ABB Ltd, Zurich, and Jonathan Eckart, Project Lead for the Global Battery Alliance and a Global Leadership Fellow at the World Economic Forum, estimate that when comparing the entire life cycle of EVs to the entire life cycle of traditional ICEs, EVs average 30–60% less emissions than ICEs.[22]

The latest technology for EVs incorporates lithium-ion batteries (LIBs), which are utilized for their rechargeability and high

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[18] Andrew A. Irvine, *The Electric Vehicle Movement–How Policy and Regulations are Fueling Momentum Impacts on the Global Energy and Mining Industries*, INTERNATIONAL MINING AND OIL & GAS LAW, DEVELOPMENT, AND INVESTMENT, 2019 No. 3 RMMLF-INST 15A, 1 (Apr. 10-12, 2019).

[19] Jeff Spangenberg, Dir. ReCell Ctr., Argnonne Nat'l Lab'y., Dep't of Energy Vehicle Tech. Off., Presenter at the A.B.A. Env't, Energy, & Res. Section's Achieving Sustainability in Electric Vehicle Transp.: Emerging Issues (Nov. 19, 2020).

[20] Jonathan Eckart, *Batteries Can Be Part of the Fight Against Climate Change - If We do These Five Things*, WORLD ECONOMIC FORUM (Nov. 28, 2017), https://www.weforum.org/agenda/2017/11/battery-batteries-electric-cars-carbon-sustainable-power-energy/ [https://perma.cc/S2E5-VUK4] (last visited Feb. 6, 2021). (Jonathan Eckhart is a Project Lead for Global Battery Alliance, an international World Economic Forum (WEF) partnership of seventy members connected with global battery supply chains including both public and private sector stakeholders. Eckart is also a Global Leadership Fellow for the WEF.)

[21] IRVINE, *supra* note 18, at 9.

[22] Frank Mühlon and Jonathan Eckart, *The Decade of Electrification: How EVs Can Keep Us On The Road To Paris*, FORBES MAGAZINE (Sep. 9, 2020), https://www.forbes.com/sites/worldeconomicforum/2020/09/09/the-decade-of-electrification-how-evs-can-keep-us-on-the-road-to-paris/?sh=139403a47423 [https://perma.cc/9EUZ-WV43] (last visited Feb. 7, 2021).

energy storage and output.[23] The EV LIBs are created from extracted raw materials sourced outside of the U.S. that must be smelted to refine the extracted ores into battery-grade components for the EV LIBs.[24] EV LIBs are quite large and weigh between 600 to 1,200 lbs.[25] and rest within the frame of the vehicle.[26]

While the average EV has a useful life span of approximately ten years, EV LIBs are not easily recycled yet.[27] Ten years is an average figure, and notably, batteries degrade more quickly in very hot conditions.[28] Vehicle electrification expert, Jeremy Michalek, states that EVs, on average, consume about 15% more energy per mile when driven in extreme weather regions such as Phoenix,

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[23] Alexander Sonoc et al., *Opportunities to Improve Recycling of Automotive Lithium Ion Batteries*, 29 Procedia CIRP 752 (2015).

[24] Spangenberg, *supra* note 19.

[25] Jeff Farano Sr., General Counsel, SA Recycling, Member, Institute of Scrap Recycling Industries, Presenter at the A.B.A. Env't, Energy, & Res. Section's Achieving Sustainability in Electric Vehicle Transp.: Emerging Issues (Nov. 19, 2020).

[26] Laura Wagner, Battery Life Cycle Manager, Ford Motor Co., Presenter at the A.B.A. Env't, Energy, & Res. Section's Achieving Sustainability in Electric Vehicle Transp.: Emerging Issues (Nov. 19, 2020).

[27] Spangenberg, *supra* note 19.

[28] Karin Heineman, *Extreme Weather Affects an Electric's Car's Range,* INSIDESCIENCE.ORG (Nov. 12, 2015), https://www.insidescience.org/video/extreme-weather-affects-electric-cars-range [https://perma.cc/5M66-F3NL] (last visited Feb. 6, 2021). (Jeremy J. Michalek directs the Vehicle Electrification Group and the Design Decisions Laboratory and serves as an active member of the Green Design Institute, the Electricity Industry Center and the Center for Climate and Energy Decision Making. His research focuses on technical, economic, environmental, and policy dimensions of energy and transportation systems as well as systems optimization and consumer choice modeling. Michalek earned his B.S. from Carnegie Mellon (1999) and his M.S. (2001) and Ph.D. (2005) from the University of Michigan in Mechanical Engineering. He worked as a postdoctoral research fellow at the University of Michigan before beginning his current faculty position at Carnegie Mellon. At Carnegie Mellon he is Professor of Engineering and Public Policy and Professor of Mechanical Engineering. Additionally, Michalek's full Carnegie Mellon University biography can be viewed through the University's faculty wiki https://wiki.ece.cmu.edu/ddl/index.php/Jeremy_J._Michalek.)

Arizona, or Minneapolis, Minnesota,[29] and EVs that consume more energy will have a lower range.[30] In fact, during peak days where temperatures are at their extreme, the range could drop by 40% or more.[31] Thus, vehicles with a normal hundred-mile range might only have a sixty-mile range on an extreme weather day.[32] Nissan Leaf, an EV available in 40 kWh and 60 kWh variants, normally averages just under 200 miles of range,[33] which would theoretically drop to about 120 miles of range during extreme temperature driving.[34] The Long Range Tesla Model 3, capable of over 300 miles of range and a 75 kWh battery pack,[35] could be reduced to 180 miles of range.[36]

With an average maximum lifespan of ten years or less, depending on an EV's operating climate, examining geographical sales data can help forecast the number of spent EV LIBs the nation will be facing.[37] In December of 2010, Nissan introduced the Nissan Leaf as the first fully electric vehicle available for purchase in the U.S. market.[38] Within eight years of the Nissan Leaf's debut, more

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[29] *Id.*
[30] *Id.*
[31] *Id.*
[32] *Id.*
[33] Matthew Beedham, *EV Battery Basics: All You Need to Know About kW, kWh, and Charging Speed*, THE NEXT WEB (Feb. 5, 2021), https://thenextweb.com/shift/2020/07/21/ev-battery-basics-kw-kwh-electric-vehicle-charging-lingo/ [https://perma.cc/J6KJ-H437] (last visited Feb. 7, 2021).
[34] *See generally* HEINEMAN *supra* note 28. (Calculating the Nissan Leaf's range of miles reduction for operation of EVs in extreme weather conditions or climates based upon Jeremy Michalek's research.)
[35] BEEDHAM *supra* note 33.
[36] *See generally* HEINEMAN *supra* note 28. (Calculating the Tesla Model 3's range of miles reduction for operation of EVs in extreme weather conditions or climates based upon Jeremy Michalek's research.)
[37] Perry Gottesfeld, *Opinion: Electric Cars' Looming Recycling Problem.* UNDARK.ORG (Jan. 21, 2021), https://undark.org/2021/01/21/electric-car-looming-recyclability-problem/ [https://perma.cc/5PYK-U4VA] (last visited Feb. 7, 2021). (Perry Gottesfeld is the executive director of Occupational Knowledge International and a member of the California Environmental Protection Agency's Lithium-ion Car Battery Recycling Advisory Group.)
[38] Nissan, Global News, https://www.nissan-global.com/EN/NISSAN/LEAF/ [https://perma.cc/YS2J-AMRR] (last visited Feb. 7, 2021).

than forty manufacturers now supply either fully EV or hybrid plug-in vehicles to the U.S. market.[39] By 2018, the one-millionth EV was sold in the U.S. and crossed the sales threshold much sooner than many expected.[40] In 2019, 727,000 EVs were sold[41] and Nissan, Chevrolet, and Tesla account for more than 60% of current U.S. EV sales.[42] On a broader scale, tech analysts for financial giant Morgan Stanley, anticipate global EV sales to grow 50% or more in 2021, while sales of ICE vehicles are only expected to grow between 2–5%.[43]

These statistics are provided to show that, as a nation, the U.S. will embrace electric vehicles, and with that, will face a new problem from a flood of spent EV LIBs. To date, the U.S. lacks well-defined state and federal legislation and regulations to mandate the safe recycling or disposal of EV LIBs.[44] Spent EV LIBs not only have hazardous materials in them but also carry a lethal voltage requiring special tools and training to remove the large battery systems from their respective EV models.[45] The energy storage of

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[39] EnelX, *Who Are the Top Electric Car Companies*, JUICEBLOG (Oct. 19, 2018), https://evcharging.enelx.com/eu/about/news/blog/492-top-electric-cars [https://perma.cc/X7P6-DZW8] (last visited Feb. 7, 2021).
[40] *Id.*
[41] USA Facts, *How Many Electric Cars are on the Road in the United States?,* USAFACTS.ORG (Oct. 22, 2020), https://usafacts.org/articles/how-many-electric-cars-in-united-states/ [https://perma.cc/M5WH-KZX3] (last visited Mar. 28, 2020).
[42] ENELX, *supra* note 39.
[43] Claudia Assiss, *Electric Vehicle Sales Expected to Grow 50% in 2021*, MARKET WATCH (Dec. 20, 2020) https://www.marketwatch.com/story/electric-vehicle-sales-expected-to-grow-50-in-2021-11607710053 [https://perma.cc/TBM4-6FMH] (last visited Feb. 7, 2021).
[44] Farano, *supra* note 25.
[45] *Id.* (During the American Bar Association's Environment, Energy, & Resource Section's. "Achieving Sustainability in Electric Vehicle Transportation: Emerging Issues" presentation on Nov. 19, 2021, Farana spoke as a representative for the Institute of Scrap Recycling Industries, Inc. (ISRI) and in Farano's capacity as corporate counsel for SA Recycling, LLC in Anaheim, California. SA Recycling has multiple scrap yards and is a large scrap recycling operation in southern California. California is the U.S. state with the highest amount of EVs on the road and the longest EV purchasing history. SA

current EV LIBs in U.S. EVs varies between 350 and 400 volts depending on the make and model.[46] For comparison, electrocution from household outlets with only 110 volts is potentially fatal to humans.[47] Furthermore, the complex battery systems consist of modules housing the LIBs in connected series which are welded, fastened, or glued, and interwoven with sophisticated battery management systems to monitor and control the temperature of EV LIBs within the battery pack modules.[48] Current robotic technology does not have the ability to dismantle complex battery systems because unscrewing or dealing with bonding methods and fixtures requires working with sensitive battery components and creating complicated dynamics and control problems,[49] such as simultaneous force and motion control.[50] However, technology experts anticipate robotic dismantling to be achieved in the future.[51]

Currently, human laborers conduct the removal of EV LIBs, and mistakes leading to the puncture of the modules can create fires or explosions.[52] Improper removal techniques or careless handling of LIBs are dangerous.[53] It is likely that the dismantling of EV LIBs

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Recycling is already experiencing issues with spent or damaged EV LIBs stockpiling in SA's scrap yards. Farana's PowerPoint pictures and personal descriptions explained how traditional internal combustion engine automobiles are disassembled and shredded and warned of the potential for serious injury or combustion if the same scrap recycling techniques are purposefully or inadvertently employed with EVs with the LIBs still intact.)

[46] *Id.*

[47] Mihaela Ungureanu, MD., *Electrocutions--Treatment Strategy*, JOURNAL OF MEDICINE AND LIFE, VOL. 7, ISS. 4., 623–626 (2014), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4316151/pdf/JMedLife-07-623.pdf, [https://perma.cc/LB2T-M4BG] (last visited Feb. 7, 2021).

[48]Farano, *supra* note 25.

[49] André Gonçalves, *How Long Does and Electric Car Battery Last? What Happens at Disposal and Recycling?*, YOUMATTER, Energy & Transport Section (Mar. 9, 2020), https://youmatter.world/en/electric-car-battery-recycling-lifespan/ [https://perma.cc/VY72-8G3W] (last visited Feb. 7, 2021).

[50] *Id.*

[51] *Id.*

[52] Kong, L., et al., *Li-ion Battery Fire Hazards and Safety Strategies*, Energies, 11, 2191 (2018).

[53] *See* Farano *supra* note 45.

fall squarely under the purview of the Occupational Health and Safety Administration.[54] However, as of January 2021,[55] there are no definitive federal legislation or regulations to mandate the dismantling, recycling, or disposal of these essential yet complex EV LIBs.[56]

While manufacturers continue to innovate to meet the growing demand from EV customers, self-governing communities could offer powerful solutions. One such community, Orlando, Florida, is a burgeoning city whose population has grown 20.4% between 2010 and 2019 with nearly 288,000 residents at present.[57] Located within Orange County, Florida, with a cumulative 1.39 million residents,[58] Orlando is also a modern city dedicated to promoting technological innovation, sustainability, and renewable energy advancements.[59]

In 2017, Orlando's mayor, Buddy Dyer, along with the city commissioners proposed and approved an energy plan committing the city to be fueled by 100% renewable energy by 2050.[60] Mayor

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[54] *Id.*

[55] GOTTESFELD, *supra* note 37.

[56] Lauren Neuhaus, *The Electrifying Problem of Used Lithium Ion Batteries: Recommendations for Recycling and Disposal*, 42 ENVIRONS ENVTL. L. & POL'Y J. 67. (2018).

[57] U.S. Census Bureau, *Florida; Orlando city; Orange County, Florida*, QUICKFACTS, https://www.census.gov/quickfacts/fact/table/FL,orlandocityflorida,orangecountyflorida/PST045219 [https://perma.cc/45VE-LN5F] (last visited Dec. 12, 2020).

[58] *Id.*

[59] Press Release, Buddy Dyer, Orlando Mayor Buddy Dyer Announced City of Orlando Solar Energy Commitment at OUC Solar Farm Dedication (Dec. 7, 2017), http://www.cityoforlando.net/news/2017/12/orlando-mayor-buddy-dyer-announced-city-of-orlando-solar-energy-commitment-at-ouc-solar-farm-dedication/ [https://perma.cc/VZ4P-CAYY] (last visited Feb. 7, 2021).

[60] Press Release, Buddy Dyer, Orlando Mayor Buddy Dyer Joins International & National Campaigns, Reaffirming the City of Orlando's Goal of Using Clean Energy and Reduce Greenhouse Gas Emissions (May 31, 2017), http://www.cityoforlando.net/news/2017/05/orlando-mayor-buddy-dyer-joins-international-national-campaigns-reaffirming-the-city-of-orlandos-goal-of-using-clean-energy-and-reduce-greenhouse-gas-emissions/ [https://perma.cc/JWJ9-PXNP] (last visited Feb. 7, 2021).

Dyer is one of 226 mayors across the nation who accepted the challenge to partner with the Sierra Club and the club's "Mayors for 100% Clean Energy" initiative.[61] In 2018, the city updated its Community Action Plan (CAP) to reflect its sustainability commitments making the CAP one of the first in America to both inform and align its strategies with United Nations Sustainable Development Goals in order to advance critical global efforts.[62]

This comment outlines the posture of sustainability-committed municipalities in promoting valuable second-life reuse options for EV LIBs and why that solution is necessary. Furthermore, this comment proposes that Orlando is able to lead the charge as a pioneer city by incorporating immediate action to face the challenge of spent EV LIBs just beginning to enter U.S. waste streams. By linking the city's commitments to sustainability, renewable energy, and innovation, Orlando has an opportunity to show other cities in Florida and across the U.S. how local self-governed municipalities can solve newly evolving issues associated with these advancing technologies in the void of federal and state legislation, regulations and mandates.

Part I provides background information on EV LIBs, their life cycles, their current recycling methods, and the lack of legislation and regulation regarding the batteries' disposal. Part II discusses using Orlando as a pioneer city to model second-life reuse options for EV LIBs in conjunction with other progressive sustainability projects the city has already implemented. Part III summarizes the importance of having and using partnerships to develop short-term solutions to the impending problem of stockpiles of spent batteries. Part IV analyzes the city's municipal utilities' governing powers and limitations to implementing new strategies. Part V summarizes this comment's proposal by outlining similarly situated cities in Florida and in the U.S. citing how Orlando is poised to set an example for municipalities to promote second-life uses.

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[61] *Id.*

[62] City of Orlando, *2018 Community Action Plan*, https://www.orlando.gov/Initiatives/2018-Community-Action-Plan [https://perma.cc/46DN-4LPK] (last visited Dec. 13, 2020).

II. BACKGROUND

A. How Does an EV LIB Work?

Electric vehicles are induction machines which harness energy to power the vehicle via electrochemical potential, the tendency of a material to lose its electrons.[63] Batteries operate by having a cathode, or electron losing material paired with an anode, or electron gaining material thereby creating a flow of electricity.[64] In an EV LIB, the EV battery is depleted when the electron movement between the LIBs internal battery chemistries have reduced to a flow state below that which is required to power the EV.[65] Charging the EV LIB occurs by plugging into an outside electrical current so that the rechargeable EV LIB once again ionizes the internal battery materials sending a flow of electrons from a slow or rested state to a charged state. As soon as the EV is unplugged, the natural electrochemical potential of the battery is released, electrons flow once again creating the power necessary to operate the EV. Electrochemical potential is an emission-free process on its own which operates EVs without all of the traditional moving parts that ICEs require. The reduced GHG emissions during operation and the reduction of moving parts subject to wear and repair are big selling points to EV consumers.

B. What Is a Product Life Cycle Analysis and Why Do We Care?

Understanding the life cycle of EV LIBs highlights the immediacy of implementing reuse options proposed by this

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[63] *See* Chaofeng Liu, et. al, *Understanding Electrochemical Potentials of Cathode Materials in Rechargeable Batteries*, MATERIALS TODAY, Vol. 19, Iss. 2., 109, 122 (Mar. 2016). (General discussion on how electrochemical potential is derived and used in rechargeable batteries.)

[64] *Id.*

[65] Christopher Lampton, *How Electric Car Batteries Work*, HOW STUFF WORKS, https://auto.howstuffworks.com/fuel-efficiency/vehicles/electric-car-battery.htm [https://perma.cc/9RYX-3GYG] (last visited Mar. 28, 2021).

comment. The international standardized ISO 14040/14044[66] outlines a Life Cycle Assessment (LCA or Life Cycle Analysis) as an instrument of environmental and sustainability management.[67] An LCA's industrial purpose is the comprehensive life cycle evaluation of products and services in order to increase product sustainability.[68] However, methodical evaluation of LCAs also assists to calculate the environmental impact of a product over its entire life cycle, from cradle to grave.[69] LCAs are useful to evaluate both products or services and include the overlap of production systems[70] that are prevalent in manufacturing across related industries. LCAs consider a product or service from resource extraction to production, use, and disposal, employing integrated evaluations of all inputs and outputs to ensure negative environmental impacts are not just shifted to other life cycle phases of the product.[71]

The initial portions of a product's history are referred to as the product's "cradle." At the other end of a product's life cycle, once usefulness has been exhausted, analyzing the life cycle provides insight into end-of-life options. End-of-life options include closing the life cycle "loop" through complete reuse or recycling of the product or its components or confronting the product's ultimate disposal referred to as its "grave." The grave is a nonproductive end-of-life option and for products that contain hazardous materials

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[66] *See generally* International Organization for Standardization, *Environmental Management Life Cycle Assessment Principles and Framework,* ISO 14040:2006(E), Second edition 2006-07-01, pages 6-10, http://pqm-online.com/assets/files/lib/std/iso_14040-2006.pdf [https://perma.cc/6J7S-PJWW] (last visited Feb. 7, 2021). (The ISO sets and publishes ISO standards for global collaboration. The organizational reference provides the latest version of international standards for using LCAs in general for environmental impacts of products and services as of the time of this publication.)
[67] Ifu Hamberg, *Life Cycle Assessment*, INSTITUTE FOR ENVIRONMENTAL IT, https://www.ifu.com/en/life-cycle-assessment/ [https://perma.cc/P4ES-T7ZU] (last visited Jan. 29, 2021).
[68] *Id.*
[69] *Id.*
[70] *Id.*
[71] *Id.*

where environmental health and safety issues pose heightened dangers.[72] Additionally, U.S. lawmakers even recognize that "[i]f hazardous waste management is improperly performed in the first instance, corrective action is likely to be expensive, complex, and time-consuming."[73]

In the wake of social justice and environmental awareness, a slight variation of traditional LCA's called "social life cycle assessments" (S-LCAs) could add value to responsible decision-making.[74] S-LCAs incorporate the cost of human rights violations as well as environmental injustices caused during a product or service's life cycle.[75] This approach can be expanded to evaluate supply chains, extraction, and potential contaminations during extraction processes, evaluate the processes for refining the elements of each of a product's components, examine associated transportation or shipping, and human rights or environmental injustice impacts associated with extruded materials.[76]

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[72] 40 C.F.R. § 265.53. (Requires that Transport, Storage, and Disposal Facilities managing hazardous waste materials must, for health and safety reasons, maintain emergency contingency plans at the facilities (§ 265.53(a)), and submit those plans to all local police departments, fire departments, hospitals, and State and local emergency response teams that may be called upon to provide emergency services (§ 265.53(b).))

[73] 42 U.S.C.A. § 6901(6) (West).

[74] Claudia Peña, et al., *Using Life Cycle Assessment to Achieve a Circular Economy*, THE INTERNATIONAL JOURNAL OF LIFE CYCLE ASSESSMENT (Jan. 20, 2021), (Position Paper unnumbered) https://link.springer.com/epdf/10.1007/s11367-020-01856-z?sharing_token=2QX8qiAIvedyoU7WGQEBe_e4RwlQNchNByi7wbcMAY6Oc0FQbp2OxHnjpSajI553ko1HFotcSUWfuqSYtclRdghYDgMUmbO6zIcXDrdymVd7tjCR4T9HgKdSmSGlokidQ_AV2wiIDYotBXb2OzXKWC7GFV7DBGPMIW9FDgFDGSw%3D [https://perma.cc/H65U-TC66] (last visited Feb. 7, 2021).

[75] *Id.*

[76] *Id.*

C. *How EV LIBs are Recycled*

1. *Pyrometallurgical Recycling is the Most Common Approach*

Currently, EV LIBs are recycled through three processes: pyrometallurgical (pyro); hydrometallurgical (hydro); and direct recycling, also called "closed-loop recycling."[77] Pyro and hydro recycling processes are active industrial techniques, while direct recycling is the ideal closed-loop process which is still in the testing and pilot phase.[78] Since lithium-ion batteries power all EVs sold in the United States,[79] it is important to note that not all EV LIBs have the same material compositions.[80] The most common composition used in EV LIBs is a lithium-nickel-manganese-cobalt oxide (Li(NiMnCo)O2 or NMC),[81] but lithium-nickel-cobalt-aluminum oxide (Li(NiCoAl)O2 or NCA) is used in the best-selling EVs in the U.S. such as Tesla Models S, X, and 3.[82] There are four other typical lithium-ion battery chemistries that are also used: lithium cobalt oxide (LCO); lithium iron phosphate (LFP); lithium manganese

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[77] Spangenberg *supra* note 25.
[78] Mengyuan Chen, et al., *Recycling End-of-Life Electric Vehicle Lithium-Ion Batteries*, JOULE, Joule 3 Issue 11, 2628 (Nov. 20, 2019), https://www.sciencedirect.com/science/article/pii/S254243511930474X [https://perma.cc/42A8-QX27] (last visited Feb. 7, 2021).
[79] David Coffin and Jeff Horowitz, *The Supply Chain for Electric Vehicle Batteries*, UNITED STATES INTERNATIONAL TRADE COMMISSION JOURNAL OF INTERNATIONAL COMMERCE AND ECONOMICS, 3 (Dec. 2018), https://www.usitc.gov/publications/332/journals/the_supply_chain_for_electric_vehicle_batteries.pdf [https://perma.cc/Y9MF-QQCT] (last visited Feb. 7, 2021).
[80] *Id.*
[81] *Id*.
[82] *Id.*

oxide (LMO);[83] and lithium titanate (LTO).[84] Having different and rapidly evolving chemistries introduces unique difficulties for recyclers and researchers alike.[85]

Pyro recycling, a two-step process, includes first, high-temperature smelting to separate the organic and inorganic materials of the batteries, then a subsequent separation step of the recoverable materials through a hydro recycling process.[86] Pyro recycling produces efficient recovery of precious metals, such as cobalt (Co), nickel (Ni), and copper (Cu).[87] The main disadvantages to pyro processing are CO_2 generation, high energy consumption during the smelting process, the two-step process to recover materials, and the inability to recover plastics, graphite, and aluminum.[88] Although pyro recycling does recover Co and Ni from cathode materials and Cu from anodes, the amount recovered only accounts for approximately 30% of the EV LIBs weight of electronics.[89] Lastly, as EV LIB manufacturers continue to find alternative chemical compositions with little to no Co, the cost of pyro-processing of EV LIBs in the absence of Co recovery tends to exceed the financial return of recycling.[90]

2. *Hydrometallurgical Recycling Recovers the Most Material*

Hydro recycling is achieved using aqueous chemistry, via leaching in acids or bases in calculated concentrations and with

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[83] Marcy Lowe, et al., *Lithium-ion Batteries for Electric Vehicles: The U.S. Value Chain*, CENTER ON GLOBALIZATION GOVERNANCE & COMPETITIVENESS, 30 (Oct. 5, 2010), https://unstats.un.org/unsd/trade/s_geneva2011/refdocs/RDs/Lithium-Ion%20Batteries%20(Gereffi%20-%20May%202010).pdf [https://perma.cc/7BYU-88WX] (last visited Mar. 28, 2021).
[84] *Id.* at 66.
[85] CHEN et al., *supra* note 78 at 2628.
[86] *Id.*
[87] *Id.*
[88] *Id.* at 2627.
[89] *Id.* at 2628.
[90] *Id.* at 2627.

subsequent purifications.[91] Examples of various hydro recycling technologies include ion exchange, solvent extraction, chemical precipitation, and well as electrolysis.[92] There are several key advantages to hydro recycling, such as generating recycled materials of higher purities in which much of the LIB constituents can be recovered.[93] Hydro processing also involves a low-temperature operation with lower CO_2 emissions compared to pyro processing.[94] Primary disadvantages to hydro recycling processes include: a need for sorting that requires increased storage space and adds to process cost and complexity; the challenge of separating some elements (Co, Ni, Mn, Fe, Cu, and Al) in the solution due to their similar properties, which can lead to higher costs; and the expense of wastewater treatment and associated costs.[95]

3. Direct Recycling is a Collaborative International Goal

The goal for EV LIBs, getting to get to direct recycling, means closing the life-cycle loop and recovering battery-grade materials from spent EV LIBs.[96] Direct recycling harvests and recovers active materials while retaining their original compound structure.[97] If direct recycling can be achieved, the main advantages include direct reuse of battery-grade active materials with lower emissions and less secondary pollution than with traditional pyro and hydro recycling.[98] The disadvantages of direct recycling,

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[91] *Id.* at 2630.
[92] *Id.*
[93] *Id.*
[94] *Id.*
[95] *Id.*
[96] Wagner *supra* note 26. (Laura Wagner as the Battery Life Cycle Manager for Ford Motor, Co. explained that for Ford to take back and recycle their EV batteries as of fall 2020, the cost is approximately $1,000–2,000 per vehicle and does not provide enough battery grade materials to absorb the cost. Most of the recoverable materials is deemed ‘black sand’ or ‘black mass’ which is an iron dense mixture that is suitable for re-use in steel production.)
[97] CHEN et al., *supra* note 78 at 2635.
[98] *Id.* at 2636.

however, are numerous and include rigorous sorting and pre-processing based on exact active material chemistry.[99] There are challenges to guaranteeing consistent high purity and pristine crystal structures also which may not meet the standards required by the battery industry.[100] Direct recycling of EV LIBs is a predominantly unproven technology that, thus far, exists only in labs.[101]

Furthermore, direct recycling is an inflexible process with significant sensitivity to input stream variations.[102] Since what goes into the process is what comes out, meeting the changing cathode chemistries is difficult because active materials recovered will be ‘‘old technology’’ and may no longer be relevant.[103] In the near term, this technology is more likely to be adopted by battery manufacturers for recycling electrode scraps where the chemistry is known and current.[104] Finally, pyro and hydro are the only processes employed by active recyclers, while direct recycling is still only conducted in laboratory research and development or in pilot testing.[105]

D. Legislation and Regulations Regarding EV LIBs

1. Regulation of EV LIBS During Transport and On the Road

The top manufacturers of EV LIBs for U.S. auto manufacturers are LG Chem, a global top tier-1 producer of lithium-ion batteries for electric vehicles,[106] and Panasonic, Tesla’s current

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[99] *Id.*
[100] *Id.*
[101] *Id.*
[102] *Id.*
[103] *Id.*
[104] *Id.*
[105] *Id.* at 2627.
[106] Global X, *4 Companies Leading the Rise of Lithium and Battery Technology*, SEEKING ALPHA (Dec. 21, 2020), https://seekingalpha.com/article/4395608-4-companies-leading-rise-of-lithium-and-battery-technology [https://perma.cc/8KG5-TUTQ] (last visited Jan. 30, 2021).

primary battery supplier.[107] With Tesla being the exception by assembling their EV battery systems with imported Panasonic rolled cells,[108] all other EV LIBs are imported to the U.S.[109] primarily from Asian manufacturers in large wooden shipping containers.[110] Once within U.S. jurisdiction, the U.S. Department of Transportation (DOT) regulates the batteries' transportation within the U.S., to their respective auto manufacturing plants.[111] Lithium batteries as a whole are regulated as hazardous material under the U.S. Department of Transportation's (DOT's) Hazardous Materials Regulations (HMR), 49 C.F.R., Parts 171-180.[112] The HMR applies to any material DOT determines may pose an unreasonable risk to health, safety, and property when transported in commerce.[113] Lithium batteries alone, or those already assembled into their respective products, must conform to all applicable HMR requirements when transported by air, highway, rail, or water.[114]

Lithium batteries present both chemical and electrical hazards.[115] Dangers include chemical burns, fire, and electrical shock.[116] Batteries can be dangerous if not safely packaged and handled when transported.[117] Misused, mishandled, improperly packaged, improperly stored, overcharged, or defective batteries can

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[107] Ellen R. Ward, *How Can Tesla, Nikola Set the Future of Electric Vehicles If They Don't Own the Batteries?*, FORBES MAGAZINE ONLINE, (Sep. 16, 2020), https://www.forbes.com/sites/ellenrwald/2020/09/16/how-can-tesla-nikola-set-the-future-of-electric-vehicles-if-they-dont-own-the-batteries/?sh=46ebe42c3a4e [https://perma.cc/K7ZZ-K3B3] (last visited Feb. 7, 2021).
[108] *Id.*
[109] Wagner, *supra* note 26.
[110] *Id.*
[111] *Id.*
[112] U.S. Department of Transportation, *Transporting Lithium Batteries*, PIPELINE AND HAZARDOUS MATERIALS SAFETY ADMINISTRATION, https://www.phmsa.dot.gov/lithiumbatteries [https://perma.cc/XDY7-7R4N] (last visited Mar. 27, 2021).
[113] *Id.*
[114] *Id.*
[115] *Id.*
[116] *Id.*
[117] *Id.*

short-circuit, overheat, and sometimes cause a fire.[118] Most lithium batteries manufactured today contain a flammable electrolyte and have a high energy density.[119] They can overheat and ignite under certain conditions and, once ignited, can be difficult to extinguish.[120] In addition, although an infrequent event, a lithium battery is susceptible to thermal runaway which is a chain reaction leading to a violent release of its stored energy.[121] If any of these lithium battery issues affect EV owners on the road or even while parked, the National Highway Transportation and Safety Administration (NHTSA) regulates the recall notifications for auto manufacturers and customers.[122] Additionally, the NHTSA oversees general safety regulations for all vehicles and drivers on U.S. roads,[123] and the Consumer Product Safety Act (CPSA) dictates minimum safety standards[124] for all products sold in the U.S. stream of commerce.[125]

2. Regulation of EV LIBS Recycling and Disposal

There is no precise legislation nor regulations mandating specific recycling or disposal of spent EV LIBs as of the time of this comment.[126] However, waste streams in general are first analyzed

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[118] *Id.*
[119] *Id.*
[120] *Id.*
[121] *Id.*
[122] 49 C.F.R. § 1.94; *See also* 49 U.S.C. 322.
[123] *Id.*
[124] *See* 15 U.S.C.A. § 2052, 5(C) (West)**.** (Motor vehicles or motor vehicle equipment (as defined by section 30102(a)(6) and (7) of Title 49)); *See also* 49 U.S.C.A. § 30102, §§ 9–10 (West). ((9) "motor vehicle safety" means the performance of a motor vehicle or motor vehicle equipment in a way that protects the public against unreasonable risk of accidents occurring because of the design, construction, or performance of a motor vehicle, and against unreasonable risk of death or injury in an accident and includes nonoperational safety of a motor vehicle. (10) "motor vehicle safety standard" means a minimum standard for motor vehicle or motor vehicle equipment performance.)
[125] 15 U.S.C.A. § 2052 (West)**.**
[126]Spangenberg, *supra* note 19. (Jeff Spangenberg is the Director of the ReCell Center at Argonne National Laboratories (ANL). The ReCell Center was opened

under the Resource Conservation and Recovery Act (RCRA), which provides federal guidelines for state regulation of municipal solid waste (MSW),[127] and mandates federal minimum standards concerning hazardous waste to be implemented by all U.S. states.[128] Additionally, RCRA's jurisdiction over certain activities of normal production operations or normal uses of commercial products stops just short of waste management when regulating those recycling activities.[129] Key factors to determine whether the recycling of a product has an exemption to RCRA's mandated standards are whether the recycling activity is satisfactorily comparable to product manufacturing, or whether a recycled secondary material is used in essentially the same manner as a primary commercial product.[130] In Florida, if a discarded product does not fit within a solid waste exception, it is deemed hazardous, and it is not recycled, then it shall not be disposed of in any solid waste management facility except for facilities permitted to accept the waste.[131]

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in June of 2019, created in response to a federal executive order in Dec. of 2017 titled "A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals," Spangenberg presented at the Nov. 19, 2020 American Bar Association's Environment, Energy, & Resource Section's. "Achieving Sustainability in Electric Vehicle Transportation: Emerging Issues" describing the lack of legislation and regulation as an issue for recycling but as strategic to allow EV and EV LIB manufacturers the leverage to invent and deploy the safest and most efficient batteries. Additionally, there is only one private recycler in the U.S. that recycles EV LIBs.; *See generally* Exec. Order No. 13,817, 82 Fed. Reg. 60,835 (Dec. 26, 2017), https://www.federalregister.gov/documents/ 2017/12/26/2017 -27899/a-federal-strategy-to-ensure-secure-and-reliable-supplies-of-critical-minerals [https://perma.cc/5MNJ-SJH6] (last visited Mar. 28, 2021).; *See also* Farano, *supra* note 25.; *see* GOTTESFELD, *supra* note 37.; *see* NEUHAUS, *supra* note 56.)

[127] 42 U.S.C. 82 (Sub. D. RCRA).

[128] 42 U.S.C. 82 (Sub. C. RCRA); 40 CFR §§ 260 et. seq.

[129] R. Michael Sweeney, *Reengineering RCRA: The Command Control Requirements of the Waste Disposal Paradigm of Subtitle C and the Act's Objective of Fostering Recycling-Rethinking the Definition of Solid Waste, Again*, 6 DUKE ENVTL. L. & POL'Y F. 1, 6–7 (1996).

[130] *Id.*

[131] FLA. ADMIN. CODE ANN. R. 62-701.300.

Just as spent 40 lb. lead-acid batteries are categorized as hazardous waste,[132] the characteristics of the spent EV LIBs–although much larger in size–should also fall into the hazardous waste category.[133] However, reusing spent EV LIBs as effective substitutes for commercial products may not be considered solid waste.[134] Furthermore, there is a universal waste battery exemption[135] that was implemented to address lead-acid batteries prior to a practical recycling program for them.[136] In the same manner, EV LIBs appear to fit the second subsection of 40 C.F.R. § 273.2 b, because the EV LIBs this comment addresses are not yet wasted under part 261 of this chapter, and do not meet the criteria for waste generation.[137] Additionally, the Eleventh Circuit U.S. Court of Appeals concluded in *United States v. ILCO*, that "recycled" was equivalent to "reclaimed" in the court's analysis of spent lead-acid batteries where the defendant, Interstate Lead Company, Inc. argued that by reclaiming the materials from spent lead-acid batteries, ILCO was in fact recycling and therefore not subject to RCRA hazardous waste oversight.[138] The court agreed that if the material is reclaimed and processed to recover a usable product, it is the same as recycling,[139] however, the court disagreed with the defendant regarding RCRA's scope of oversight holding that material does not have to be discarded forever, but that once is enough.[140] Additionally, it is important to note that when legally

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[132] *United States v. ILCO, Inc.*, 996 F.2d 1126, 1132 (11th Cir. 1993). (Application of [*sic.* RCRA hazardous waste] regulations to spent batteries and parts generated by consumers comports with Congress' intent in RCRA to address the problems posed by hazardous waste.)
[133] Farano, *supra* note 25.; *See generally* 40 C.F.R. § 261.2.
[134] 40 C.F.R. § 261.2, Subsection e(1)(ii).
[135] 40 C.F.R. § 273.2, Subsection b(1).
[136] Farano, *supra* note 25.
[137] 40 C.F.R. § 273.2, Subsection b(2).
[138] *ILCO, Inc.*, at 1126.
[139] Roger Freeman, *What Constitutes "Hazardous Waste" Subject to Regulation under Resource Conservation and Recovery Act (42 U.S.C.A. §§ 6901 et seq.)?*, 135 A.L.R. Fed. 197, (Originally published in 1996).
[140] *Id.*

defined "discarded" materials are sent to a metal facility, the materials constitute solid waste in the hands of the reclaiming company.[141]

3. The European Union and Chinese Extended Producer Responsibility Models for Regulating EV LIBs Recycling and Disposal

Currently, with regards to EV LIBs, the U.S. trails in legislation and regulation to enforce the recycling of spent batteries. The European Union (EU) and China both have employed extended producer responsibility (EPR) for the manufacture of electric vehicles and the batteries that power their EVs.[142] EPR places the end-of-life (EOL) responsibility of recycling and disposal of EU and China's EVs and associated EV LIBs squarely on the shoulders of the producers or manufacturers of the goods through legislation and regulations.[143] U.S. auto manufacturing evolved under many different standards over the last century and currently does not require EPRs for U.S. automakers including those manufacturing EVs.[144] An estimated 3% of the EV LIBs are actually recycled and recycling at this point is too expensive when compared to the cost of simply sourcing more newly extracted materials to build new batteries.[145] To complicate matters, there are no EV LIBs fully produced in the U.S. as of yet.[146] The technology is still rapidly developing and changing[147] and placing EPR limits on the U.S. EV manufacturers, some argue, restricts the potential breakthroughs the EV LIBs need during this critical time of innovation.[148] These factors all contribute to the potential interim problem of what to do

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141 *Id.*
142 Spangenberg *supra* note 19.
143 *Id.*
144 *Id.*
145 *Id.*
146 Wagner *supra* note 26.
147 Spangenberg *supra* note 19.
148 *Id.*

with spent EV LIBs until recycling or safe disposal can be actualized.

III. MODERN PIONEERS MAY LOOK LIKE ORLANDO, FLORIDA

A. Defining Pioneer Cities

A "pioneer city" embodies the definition of a pioneer, which Merriam-Webster's 2021 Dictionary defines as "a person or group that originates or helps open up a new line of thought or activity or a new method or technical development."[149] In Geneva, Switzerland, in November 2020, the World Economic Forum (WEF)[150] used the same term to announce that thirty-six cities across twenty-two countries and six continents agreed to pioneer a new roadmap for safely adopting new technology as part of the G20 Global Smart Cities Alliance.[151] The G20's "pioneer cities" will adopt policies for privacy protection, better broadband coverage,

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[149] Merriam-Webster, Inc. Dictionary definition of "pioneer" entry 2.a. https://www.merriam-webster.com/dictionary/pioneer [https://perma.cc/9KBE-ZUQ6] (last visited Mar. 28, 2021).

[150] The World Economic Forum is a Swiss based non-profit international organization consisting of partners from around the world who are leaders in business, industry, government and advocacy platforms for cooperation to better the international community on such topics as global climate change, COVID-19 crisis responses, and social and environmental injustice issues to name a few. WEF also conducts an annual conference in Davos, Switzerland, where the WEF put forth the latest "Davos Agenda". The last conference was conducted January 25 – 29, 2021 and launched the "Davos Manifesto" as a set of ethical principles to guide companies in the age of the Fourth Industrial Revolution.; *See also* https://www.weforum.org/about/world-economic-forum [https://perma.cc/T3WZ-2QAQ] (last visited Mar. 28, 2021).

[151] Alexandra May, *In the Face of Extraordinary Challenges, 36 Pioneer Cities Chart a Course Towards a More Ethical and Responsible Future*, WORLD ECONOMIC FORUM (Nov. 17, 2020), https://www.weforum.org/press/2020/11/in-the-face-of-extraordinary-challenges-36-pioneer-cities-chart-a-course-towards-a-more-ethical-and-responsible-future/ [https://perma.cc/FKB4-WUTC] (last visited Mar. 28, 2020).

accountability for cyber security, increased openness of city data, and better accessibility to digital city services for disabled and elderly people.[152] The pioneer cities are set to change with the launch of a new global policy roadmap developed by the G20 Global Smart Cities Alliance, designed to give cities the procedures, laws, and regulations they need to use new technology responsibly.[153]

Jeff Merritt, Head of the Internet of Things and Urban Transformation, WEF, stated that the "[r]oadmap is not about theoretical ideas and pipe dreams, it is built on practical, real-world policies from leading cities around the globe . . . [c]ity governments are on the frontline of a global crisis and need to be able to act quickly and decisively[.]"[154] Although the G20 Smart Cities Alliance is aimed at curtailing economic devastation and resource crisis as were exposed during the COVID-19 pandemic in internet and connectivity,[155] this comment proposes that Orlando could be one, if not the leading city to develop immediate short-term technological initiatives for promoting second life uses of spent EV LIBs to offset impending stockpiling of spent EV LIBs[156] as a matter of municipality function.

Technology is an essential tool used to combat the detrimental ramifications of current global devastations, but governments cannot risk falling into the usual traps that coincide with advancing technology.[157] For the G20 pioneer cities, the usual

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[152] *Id.*
[153] *Id.*
[154] *Id.*
[155] *Id.*
[156] *See* Gavin Harper, et al., Recycling Lithium-ion Batteries from Electric Vehicles, NATURE (Nov. 6, 2019), 575, 75–86 [https://perma.cc/FQY7-MR7N] (last visited Feb. 19, 2021). (Peer reviewed article outlining an overall evaluation of recycling and reuse options for EV LIBs and discusses waste issues including the foreseeable stockpiling of EV LIBs if not addressed.)
[157] Alexandra May, Public Engagement, World Economic Forum, In the Face of Extraordinary Challenges, 36 Pioneer Cities Chart a Course Towards a More Ethical and Responsible Future, https://www.weforum.org/press/2020/11/in-the-face-of-extraordinary-challenges-36-pioneer-cities-chart-a-course-towards-a-more-ethical-and-responsible-future/ (last visited Dec. 12, 2020).

technology traps relate to privacy, security and vendor lock-ins.[158] Pioneer cities provide a wealth of information on how to proceed with implementing innovative technology options and how well strategies perform. Other cities can glean from pioneer cities who document struggles in following conceptual plans, alternative solutions and lessons learned in their own implementation phases. The collaborative efforts and information sharing streamline other cities' efforts supporting the avoidance of the usual traps associated with new technological advancements. Second-life reuse of EV LIBS is not a new idea, however, there is no easily ascertained data of other cities progressively stepping up to take the initiative to face the wave of spent EV LIBs that are coming through second-life reuse as this comment suggests.

B. The Role of Pioneer Cities to Face Global Challenges

The purpose of a pioneer city is to utilize a methodology and associated term used by international powerhouse organizations, such as the WEF to implement programs to push international agendas for sustainability and enhanced services and justice. Pioneer cities are willing to represent similarly situated cities poised to highlight the proposed implementation. By establishing a pioneer city program for the promotion of second-life uses of EV LIBs, the city of Orlando can create an immediate blueprint for other similarly situated municipalities across the U.S. also facing potential stockpiles of EV LIBs as EV sales begin to outnumber traditional ICE vehicles. There are a number of ways Orlando can leverage their power, position, and partnerships to creatively reuse and even extract higher energy storage returns by collecting and reusing multiple EV LIBs of similar makes and models in discreet projects within the city's jurisdiction.

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[158] *Id.*

C. *Orlando's Ability to Lead as a Pioneer City*

1. *Orlando's Municipal Scope of Power*

Orlando is one of Florida's 412 chartered municipalities.[159] In Florida, there is no legal distinction between a city, town, or village, all three are referred to as municipalities by the state.[160] Unlike Florida's sixty-seven counties which are state subdivisions for state administration of taxation and regulation, municipalities are unique entities legally granted self-governance, including the full power of home rule.[161] Prior to 1968, home rule powers for Florida's municipalities were limited by Dillon's rule, which stated that municipalities were limited to only those provisions as outlined in a municipality's charter.[162] Powers not granted to a municipality by the legislature were deemed to be reserved for the legislature.[163] This reservation of authority was known as "Dillon's Rule," as expressed in John F. Dillon, *The Law of Municipal Corporations* § 55 (1st ed. 1872). Under the 1885 constitution, the Florida courts consistently followed Dillon's Rule.[164]

In 1968, however, Florida ratified their state constitution expanding municipalities' home rule powers so that Dillon's Rule

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[159] Florida League of Cities, Inc., *My City: I'm Part of It! I'm Proud of It!* FLORIDA LEAGUE OF CITIES CIVIC PROJECT, 7 (2018), https://www.floridaleagueofcities.com/docs/default-source/civic-education/my-city-gov-text-book-2018.pdf?sfvrsn=5517dad5_2#:~:text=One%20of%20the%20most%20fascinating,and%20no%20two%20are %20alike [https://perma.cc/J7SV-XFV8] (last visited Mar. 28, 2021).

[160] *Id.* at 6.

[161] *Id.*

[162] *City of Boca Raton v. State*, 595 So. 2d 25, 27 (Fla. 1992), modified sub nom. *Collier Cty. v. State*, 733 So. 2d 1012 (Fla. 1999), and holding modified by *Sarasota Cty. v. Sarasota Church of Christ, Inc*., 667 So. 2d 180 (Fla. 1995).

[163] *Id.*; See, e.g., *Williams v. Town of Dunnellon*, 125 Fla. 114, 169 So. 631 (1936); *Heriot v. City of Pensacola*, 108 Fla. 480, 146 So. 654 (1933); *Amos v. Mathews*, 99 Fla. 1, 126 So. 308 (1930); *Malone v. City of Quincy*, 66 Fla. 52, 62 So. 922 (1913).

[164] *Id.*

no longer prevailed.[165] By 1978, cases challenging the new parameters of home rule powers entered Florida's court system.[166] The Florida Supreme Court held in *State v. City of Sunrise* that "Article VIII, Section 2, [of the] Florida Constitution, expressly grants to every municipality in this state authority to conduct municipal government, perform municipal functions, and render municipal services. The only limitation on that power is that it must be exercised for a valid 'municipal purpose.'"[167] Florida's subsequent jurisprudence has further outlined that municipalities exist in order to provide services to its inhabitants[168] and that valid municipal purposes must relate "to the conduct of municipal government, exercise of a municipal function, or provision of a municipal service[,]"[169] which generally relates to the health, morals, safety, protection or welfare of the municipality.[170] Finding proactive solutions to potentially unsafe stockpiling of spent EV LIBs would likely fit within a valid exercise of municipality powers under Florida home rule.

2. Orlando and Municipal Energy

The city of Orlando has extensive home rule power and through its municipal utility, Orlando Utilities Commission (OUC), it is also expressly granted the ability to provide power options and infrastructure via special act.[171] OUC and Orlando are able to work creatively to supply the energy needs of the city's residents and are pre-empted only by such acts as the state's Power Plant Siting Act

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[165] *Id.*
[166] *State v. City of Sunrise*, 354 So. 2d 1206, 1209 (Fla. 1978).
[167] *Id.*
[168] *Basic Energy Corp. v. Hamilton Cty*., 652 So. 2d 1237, 1239 (Fla. Dist. Ct. App. 1995) citing *State v. City of Orlando*, 576 So.2d 1315 (Fla.1991).
[169] *Id*; *See Ormond Beach v. County of Volusia*, 535 So.2d 302, 304 (Fla. 5th DCA 1988).
[170] *Id*; *See also, City of Winter Park v. Montesi*, 448 So.2d at 1244, *citing State v. City of Jacksonville*, 50 So.2d 532 (Fla.1951).
[171] Ch. 9861, Laws of Fla. (1923).

(PPSA).[172] The PPSA however is limited to facilities and supportive operations that produce 75 megawatts (MW) of power or more in gross capacity.[173] This includes solar power generation facilities if their electrical generation qualifies as having a gross capacity of 75 MW of power.[174] Thus, to reuse EV LIBS as energy storage for any creative solar-powered structure would not trigger the PPSA unless the generation of the power associated with the structure produces the requisite 75 MW.[175]

In Florida, electric service is provided by five investor-owned electric companies, thirty-five municipally owned electric companies, and eighteen rural electric cooperatives.[176] Investor-owned utility rates and revenues are regulated by the Florida Public Service Commission,[177] but municipal electric utilities are electric utility systems owned and/or operated by a municipality engaged in serving residential, commercial, and industrial customers[178] usually within the boundaries of the municipality.[179]

Municipally owned utility rates and revenues are regulated by their city commission,[180] such is the case with the Orlando Utilities Commission (OUC). Orlando implementing valuable second-life reuse options of spent EV LIBs within the confines of their municipal utility's special act provides an example to the thirty-four other municipal utilities and possibly to the rural electric cooperatives, as well.

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[172] Florida Statutes 403.506 (1).; *See generally* Florida Department of Environmental Protection. *Power Plant Siting Act.*, https://floridadep.gov/air/siting-coordination-office/content/power-plant-siting-act [https://perma.cc/DY2Y-Z57R] (last visited Mar. 27, 2021).
[173] *Id.*
[174] *Id.*
[175] *See generally Id.*
[176] Commissioner Nicole "Nikki" Fried, Florida Department of Agricultural and Consumer Services, *Electric Utilities*, FLORIDA ENERGY CLEARINGHOUSE, https://www.fdacs.gov/Energy/Florida-Energy-Clearinghouse/Electric-Utilities [https://perma.cc/SQ7S-VS5K] (last visited Feb. 6, 2021).
[177] *Id.*
[178] *Id.*
[179] *Id.*
[180] *Id.*

OUC is rich in pioneering history as the genesis of OUC was a 1923 vote of Orlando residents to purchase the former privately-held Orlando Water & Light Company.[181] By a special act of the Florida Legislature in 1923,[182] OUC was granted full authority to operate the city's water and power plants as a municipal utility.[183] Historically, OUC lays claim to a number of groundbreaking efforts on behalf of the city of Orlando.[184] Most recently, OUC has committed to the complete cessation of coal-fuel power plants by the year 2030 and efforts are already underway to transition the coal-fuel power plants to a cleaner natural gas-powered plants.[185] Currently, there are eleven power plants in Orlando, Florida, serving an area of 103 square miles.[186] There is one for approximately every 25,000 people and one power plant for every nine square miles.[187]

Since Orlando is situated within the top 8% of Florida cities regarding power plants per capita[188] and 7% of power plants per square mile,[189] Orlando can stand as an example to the largest of Florida's cities for how to adjust conceptualizations of traditional power plants sizes and fuel sources should Orlando further innovate.

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[181] Orlando Utilities Commission (OUC), *History of OUC: Establishing an Infrastructure*, http://historyofouc.com/chapters/chapter2.php [https://perma.cc/MH5Y-QVL9] (last viewed Mar. 28, 2021).

[182] Ch. 9861, Laws of Fla. *supra* note 171.

[183] *Id*.; *See also* Orange County Municipal Code, Title I, Ch. 15., Sec. 9. Orlando Utilities Commission. https://library.municode.com/fl/orlando/codes/code_of_ordinances?nodeId=TITICH_CH15ORUTCO (last visited Feb. 6, 2021).

[184] *See generally* OUC, *History of OUC, supra* note 181.

[185] Kevin Spear, OUC's Clean-Energy Plan Criticized for Rushed Timeline, Lack of Transparency, THE ORLANDO SENTINEL (Dec. 7, 2020), https://www.orlandosentinel.com/news/environment/os-ne-ouc-energy-plan-opposed-20201207-p3r3mksxzjagbf6w2iwk7uvxky-story.html [https://perma.cc/B2YD-U2RU] (last visited Mar. 28, 2021).

[186] County Office.org, *Power Plants in Orlando Florida*, https://www.countyoffice.org/orlando-fl-power-plant/ [https://perma.cc/N926-7KJP] (last visited Mar. 27, 2021).

[187] *Id.*

[188] *Id.*

[189] *Id.*

As the city continues to modernize, the reuse of second-life EV LIBs in larger backup systems around the city could power unconventional self-standing or backup operations not preempted by the state of Florida as microgrid redistribution concepts are.

3. OUC's Active Role in EV Support and Renewable Energy

OUC has proactively responded to the increasing sales of plug-in EVs rising across the nation by ensuring Orlando is ready for them.[190] Since 2010, OUC has installed hundreds of public charging stations as part of Project Get Ready,[191] which is a collaboration between industry and government to promote the EV movement.[192] OUC claims Project Get Ready supports Orlando's role as a national leader in electric transportation and the reduction of GHGs[193] traditionally associated with ICE transportation emissions.[194] OUC also uses its own fleet of EVs for service calls and for showcasing at community events for educational purposes.[195]

OUC has also planted solar trees at key sites across their service area.[196] The trees are fully functional solar structures that OUC uses to enhance community access to renewable energy while educating Orlando customers about the unique benefits of solar power.[197] OUC has also invested in solar on bus shelters, and solar on utility poles[198] and has been an area leader in installing utility-

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190 Orlando Utilities Commission (OUC), *Championing the EV Charge*, GREEN INITIATIVES, https://ouc.com/environment-community/green-initiatives [https://perma.cc/6LH6-5UXT] (last visited Mar. 28, 2021).
191 *Id.*
192 *Id.*
193 *Id.*
194 U.S. EPA *supra* note 11.
195 OUC, *Championing the EV Charge*, *supra* note 190.
196 *Id.*
197 Orlando Utilities Commission, *Sustainability Around Town*, GREEN INITIATIVES, https://ouc.com/environment-community/green-initiatives [https://perma.cc/6LH6-5UXT] (last visited Mar. 28, 2021).
198 *Id*.

scale projects atop the Orange County Convention Center and at their Stanton Energy Center.[199] Solar energy has also been used to offset some of the needs of one of the most advanced EV infrastructures in the southeast U.S.[200] and OUC has helped install more than 150 EV charging within the southeast.[201]

4. Examples of Orlando and OUC Partnering in Power Structures

Aside from EV charging stations, solar canopies, bus shelters, and utility poles, the city of Orlando is beginning to expand clean energy projects by facilitating new forms of eco-friendly art.[202] In November of 2020, a 9.5-foot-wide by 14.5-foot-tall welded purple ball-like structure called "Gyration", was secured into place at the entrance of Orlando's Exploria Stadium.[203] The project is a collaboration of manufacturing and engineering firms, students from the University of Central Florida, and OUC.[204] The sculpture is a solar-powered structure that is capable of producing 1,264 kilowatt hours annually providing enough surplus of clean energy to light itself up at night and to offset an EV charging station.[205] Gyration was not the first eco-friendly art sculpture, but the second the city has partnered to bring to life.[206] In 2017, "Sundial" was erected in Lake Nona showcasing a 22-foot-circular structure with interactive lights and music powered by solar energy and which functions as a clock.[207]

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[199] *Id*.
[200] *Id.*
[201] *Id.*
[202] Matthew Palm, *Art, Sports and Power Meet in the New Eye-Catching Exploria Stadium Sculpture*, THE ORLANDO SENTINEL (Nov. 17, 2020), https://www.orlandosentinel.com/entertainment/arts-and-theater/os-et-orlando-soccer-stadium-sculpture-20201117-ccczx4qky5gajdvn5sethwzooi-story.html [https://perma.cc/X63E-HPHB] (last visited Mar. 6, 2021).
[203] *Id*.
[204] *Id*.
[205] *Id*.
[206] *Id*.
[207] *Id*.

Eco-friendly art sculptures supplying power for streetlighting, EV charging stations, direct access to personal charging in pedestrian-heavy public spaces such as parks or bus stops, or even used as battery backups for surrounding areas could be enhanced through second-life uses of EV LIBs. Refurbishing spent EV LIBs collected by the municipalities in conjunction with recycling or solid waste standards could provide a plethora of low-cost energy storage for a number of projects. Additionally, reuse is the most sustainable option for EV LIBs at this time.[208] Indeed, many of the first released Nissan Leaf EV LIBs are hitting their ten-year anniversary and could be reused for a myriad of new purposes.[209] These batteries are categorized by battery grades.[210] The top-tier A-grade batteries may be reused to power new EV battery units[211], B-grade batteries can be reused in short-range heavy equipment such as forklifts,[212] and C-grade batteries are feasible to reuse in backup energy storage.[213]

5. Municipalities Creating Battery Partnerships and EV LIB Collections

Municipalities may prefer to work out lease arrangements with EV LIBs manufacturers, such as Tesla, who prefer to service their company's proprietary designs[214] or establish EV battery exchanges with local dealerships or battery replacement centers. Clarifying the legal definition of EV LIBs under the universal

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[208] Kimiko Kidd, *Nissan Gives EV Batteries a New Lease on Life*, THE NEWSWHEEL (Feb. 11, 2021), https://thenewswheel.com/nissan-gives-ev-batteries-a-new-lease-on-life/ [https://perma.cc/94XB-UA6V] (last visited Mar. 6, 2021).
[209] *Id.*
[210] *Id.*
[211] Joshua Hill, *Nissan EV Batteries Get Second Life in Transport and the Grid*, THE DRIVEN, (Jan. 29, 2021), https://thedriven.io/2021/01/29/nissan-ev-batteries-get-second-life-in-transport-and-the-grid/ [https://perma.cc/293C-U8C5] (last visited Mar. 2020).
[212] *Id.*
[213] *Id.*
[214] LAMPTON, *supra* note 65.

battery waste exemption may be required however, reliance on the currently used for lead-acid battery exchanges could provide key insight. A simple definition of a microgrid is offered by the U.S. Department of Energy which defines a microgrid as a local energy grid with control capability, which means it can disconnect from the traditional grid and operate autonomously."[215]

Using solar charging trees, solar parking canopies, or even solar-powered sculptures throughout Orlando, OUC could use additional battery storage. The city is also already working to put charging spaces throughout the city and developing its first EV DC-Fast charging hub in the downtown area.[216] which would benefit from creating small localized microgrid hubs. These localized microgrids would not emit any water or air pollution and thus would not be subject to CAA or CWA permitting; additionally, the localized microgrids would not produce more than 75 MW and therefore would not be subject to Florida's Power Plant Siting Act either. The city already has creative educational partnerships with the University of Central Florida, the Florida Solar Energy Center, Valencia College, Rollins College, Florida Polytechnical University, and Orange County Public Schools.[217]

When the capacity of electric car batteries drops below 70-80% after about 10 years of use, they are no longer strong enough to power the car. But they retain enough capacity for stationary storage in various contexts: in households, to balance power plants, or to electrify off-grid communities in rural areas. However, re-purposing batteries is costly. This is due to limited information and data-sharing about the residual value of battery capacity, a lack of standards, and regulatory uncertainty about liability once the battery

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[215] U.S. Department of Energy (US DOE), *How Microgrids Work*, Energy.Gov (June 4, 2014), https://www.energy.gov/articles/how-microgrids-work [https://perma.cc/4FBH-JSC7] (last visited Feb. 6, 2021).
[216] Email from Chris Castro, Director of Sustainability, City of Orlando, to author (Nov. 23, 2020, 10:55 EST) (on file with author).
[217] *Id.*

changes owners and applications. Overcoming these barriers requires cross-industry, public-private initiatives.[218]

D. Orlando's Position Among Other U.S. Cities to Pioneer Innovation

1. Economy and Growth

Homeowners and businesses are increasingly demanding solar systems that are paired with battery storage.[219] While this pairing is still relatively new, the growth over the next five years is expected to be significant.[220] By 2025, more than 25% of all behind-the-meter solar systems will be paired with storage, compared to under 5% in 2019.[221] The utility-scale market is also recognizing the benefits of pairing solar with storage, with over eight GW of commissioned projects including storage, representing nearly one in five contracted projects.[222]

2. Five Key Factors Elevating Orlando as a Pioneer for Other Municipalities

To recap, this comment proposes using Orlando as a pioneer city due to several factors. First, Orlando is a leading city within a region of geographically connected growth zones called a metropolitan statistical area (MSA). MSAs are large urban areas consisting of a central city and several smaller municipalities, which

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[218] Eckhart, *supra* note 20.
[219] Solar Energy Industries Association (SEIA), *Storage is Increasingly Paired with All Forms of Solar*, SOLAR INDUSTRY RESEARCH DATA, https://www.seia.org/solar-industry-research-data [https://perma.cc/RUU7-H876] (last visited Feb. 6, 2021). (SEIA partners with analysts at Wood Mackenzie Power & Renewables and The Solar Foundation to tracks trends and trajectories in the solar industry that demonstrate the diversification of and the growth rates of solar across the U.S.)
[220] *Id.*
[221] *Id.*
[222] *Id.*

are dependent on the central city for jobs, services, shopping, and entertainment.[223] The successes of the individual municipalities in conglomerate growth zones positively influence each other and the failure to plan for environmental degradation will negatively impact one another. If Orlando implements a viable short-term solution to a potentially devastating problem such as reuse options for EV LIBs that keep toxic materials out of scrap metal yards and out of municipal waste streams, other municipalities can partner with Orlando or follow suit as their respective charters allow. Conversely, if Orlando fails to prepare for the interim period between now and when EV LIB recycling or safe disposal practices are available, then pollution and contamination will show how they are not respectful of city limits.

Second, Orlando is a powerful municipality that has and continues to actively pursue positive environmental programs as a state and national leader. This point is evidenced by the programs and policies already in the works for the city. According to Chris Castro, the Sustainability Director for Orlando, the city has implemented a green fleet policy that includes, for instance, unveiling their first fully EV bus for LYNX transit with an additional thirteen more to be added to the bus fleet by the end of 2021.[224] Moreover, the city is transitioning 100% of its fleet vehicles to electric and alternative fuels by 2030[225] and they currently have more than two hundred EVs in their city fleet of approximately 2,000 vehicles already.[226]

Third, Orlando is one of the few municipalities in Florida that controls its own municipal utility giving the city more flexibility to provide for the energy needs of the city's residents. Additionally, residents have actively voted for and continue to advocate for their city to consider the environment.[227] This includes amending policies and programs that residents want such as phasing out of non-

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[223] FLORIDA LEAGUE OF CITIES, Inc., *supra* note 159, at 9.
[224] Castro, *supra* note 216.
[225] *Id.*
[226] *Id.*
[227] SPEAR, *supra* note 185.

renewable fossil fuel energy supplies completely by 2050.[228] Recently, Orlando implemented a fossil fuel program shift for all power plants from coal to natural gas by 2030.[229] Although still a fossil fuel, the switch does reduce environmental degradation overall and allows time for new renewable infrastructure and energy programs to be planned and implemented.[230]

Fourth, Orlando has unique international fame that draws visitors from all over which could provide a valuable reciprocal opportunity to highlight EV LIBs reuse efforts back to visitors' places of origin.

Lastly, Orlando's climate and research atmosphere offer unique year-round testing in a predominately hot and humid climate within a corridor of high-tech learning institutions and corporations. These factors provide an ideal backdrop to test the limits of reuse options. Materials subject to Florida's intense climate must be built durable to sustain the higher temperature that degrade materials faster than in cooler climates. Additionally, the frequent severe storms, power loss, intermittent hurricanes, flooding, or other wind events such as wind sheers of tornados offer in situ disaster testing of whether second life reuses of EV LIBs are worth the effort to develop.

IV. CONCLUSION

As our technology evolves, many new green technologies will be key mechanisms to bring powerful changes to anthropocentric activities devastating the earth's climate. However, the technology, legislation, and regulation to dispose of potentially hazardous green technology saviors will bring about their own unique challenges. EVs are a recent green solution heralded by industry, governments, and environmental advocates alike, but they are made with cobalt, nickel, and manganese, among other

[228] *Id.*
[229] *Id.*
[230] U.S. EPA, *supra* note 11.

components.[231] These batteries cost thousands of dollars and come with an environmental burden: they require ingredients sourced from polluting mines and smelters around the world, and they can ultimately contaminate soil and water supplies if improperly disposed.[232]

It is important to understand these products from their product cradles to their graves so we can plan for their proper recycling or disposal or the unintended consequences of embracing them. Stockpiling of EV LIBs in auto salvage yards is already happening in states such as California[233] and it will not be long before other states face the same fate. Stockpiling these live batteries poses serious health and safety risks, but municipalities can actively reduce those risks through creative partnerships and forethought. The impending threats from climate change are only increasing, demanding the transformation of global car stocks from antiquated ICEs to a cleaner operating EVs whether safe disposal or recycling is yet actualized.

Promoting actions and policies to, first, employ informed decision-making, and, second, use creative collaboration to provide short-term and long-term solutions are essential. In Central Florida, the city of Orlando stands out as a pioneer already with progressive sustainability measures in a growing and modernizing city. If Orlando embraces creative collaboration with manufacturers, consumers, municipal utilities, and academia they stand ready to take a leadership position among other Florida cities on how to safely reuse spent EV LIBs in imaginative new ways.

We are all going to face end-of-life issues regarding EV LIBs regardless of our individual purchases of EVs ourselves. Whether we end up stockpiling spent EV LIBs in scrap yards with the hope they won't catch fire or convert them to useful second-life uses depends on whether we are willing to face the challenge together. We have the option now to encourage our own local community to address a potentially serious situation with stockpiles

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[231] GOTTESFELD, *supra* note 37.
[232] *Id.*
[233] *See* Farano *supra* note 45.

of hazardous EV LIBs. Let us work together to ensure that our decarbonization “treatment” in the transportation sector does not turn out worse than the “terminal disease” of climate change. Let us create a valuable blueprint for other cities to rise up and take charge from the ground up with action and continue to demand responsible legislation and regulations from the top down.