Electric Vehicle Battery Benefits and Harms

Olivia Xu

Introduction

As technology in automotive design continues to evolve, electric vehicles (EVs) have become more common, steadily gaining market share in the automotive industry. In 2024, over 17 million electric vehicles were sold globally, representing over 20 percent of all new vehicles [1]. The introduction of these new vehicles has been touted as a success for the environment, but emerging research in the field has highlighted concerns of resource depletion, among other potential harms. This paper examines the effects of electric vehicle batteries on the environment–first, by reviewing the current state of electric batteries and associated EV vehicle parts; and then by discussing how the materials for these parts are extracted for applications in EVs.

Parts of the EV

The main components of an electric vehicle include an electric traction motor, a thermal system, a battery, a battery traction pack, an onboard charger, a charge port, a DC-DC converter, and a power electronics converter [2]. The charge port, onboard charger, DC-DC converter, and traction battery pack all work together to harvest energy and move it throughout the vehicle. In specific, the main purpose of the charge port is to allow energy to enter; the onboard charger converts this energy from AC into DC; the DC-DC converter changes the DC power to become lower voltage for parts like accessories; and the traction battery stores power for the traction motor to use later [2]. These parts work together and ensure that the vehicle operates smoothly.

Parts of the Battery

Electric vehicle batteries are most often composed of a mixture of metals to provide an energy-dense core. A battery type commonly found in EVs is the lithium-ion battery, which is comprised of minerals like graphite and nickel [3]. Lithium-ion batteries have four main parts: the cathode, the anode, the separator, and an electrolyte.

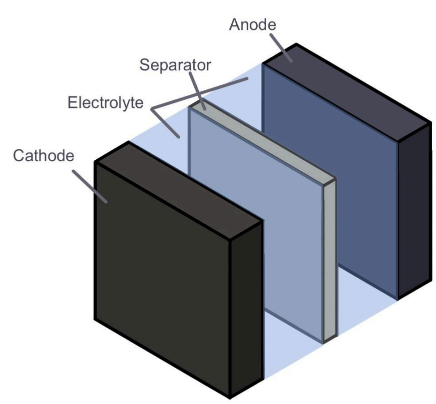

Figure 1: The figure illustrates the main parts of a lithium-ion battery (author's own)

The electrodes allowing for the flow of electric charge within the battery are the cathode–commonly made up of metal oxides, like nickel manganese cobalt (NMC) or Lithium Iron Phosphate (LFP)–and the anode, formed typically using graphite as its main component [4, 5, 6]. The cathode is a positive electrode, where electrons are gained, and the anode is the negative electrode, where electrons are lost. The electrolyte between the cathode and anode is typically a lithium salt solution, which helps facilitate the movement of lithium ions between the two electrodes [7]. When charging batteries, the cathode will begin by taking in the electrons from the charger. Then, these electrons will go through the electrolyte and travel to the anode, where they will be stored. On the other hand, when energy is being used or discharged, the electrons will travel from the anode to cathode through the electrolyte [8]. Altogether, they enable energy to transfer throughout the battery, which helps power the vehicle.

How EVs Benefit the Environment

Compared to regular gas vehicle batteries that last around 3-5 years on average, electric vehicle batteries last much longer, with around a 12-year lifespan [9, 10]. Because fewer electric batteries will be used over the same period of time in comparison to batteries in gas vehicles, EVs contribute to less battery waste. Electric vehicles in general also do not produce the same exhaust pollution as the regular gasoline car, with the average gas car emitting 12.5 thousand pounds of CO2 yearly, while electric vehicles emit an average of 2.5 thousand pounds–a difference of about 80% [11]. Such emissions contribute to air pollution, leading to the rise in atmospheric temperature. Compared to gasoline cars, electric vehicles are more energy efficient, meaning they are able to travel more distance using the same amount of energy [12].

Battery Emissions and Harms: What other research needs to be done?

The main elements in lithium-ion batteries–lithium, nickel, and carbon–are all finite resources [4]. Although the life span of an electric vehicle battery is much longer than that of a gas vehicle, the electric vehicle itself consumes six times the amount of non-renewable minerals [13]. The construction of more electric vehicle batteries may surpass the current supply on earth, resulting in depletion of these materials.

While the batteries, once they are in use, do not produce emissions, mining for the materials to make them necessitates the usage of tools, like excavators and crushers, that do [14]. The process of mining materials both emits CO_2 and utilizes much water [14]. Mining devices, like drills, run on fossil fuels, which burn and release CO_2 into Earth's atmosphere [15]. Water is then used in many ways, like helping extract lithium through evaporation or for transporting pieces of minerals [16, 17]. This process leads to increased water pollution and can cause the introduction of acid or sediments in the water [18].

A possible way to reduce emissions when mining for materials may be using renewable power sources, like wind or solar energy to power the tools, instead of fossil fuels. Solar powered mining trucks would be able to run on the energy they generate from solar panels, without the greenhouse gas emission from the burning of gasoline. Energy for mining is also expensive, taking up to forty percent of total costs [19]. Transition to renewable energy would decrease costs in the mining industry and could be implemented into later parts of the process as well, like refining the minerals [20].

How it may look in the future

Geologists have found 115 million tons of lithium resources as of January 2025, expanding the amount of supply available for use from previous years [21]. The industrial use of lithium has also gone up, increasing from 170,000 tons to 220,000 tons from 2023 to 2024 [21]. The main reason is due to the manufacturing of these electric vehicle batteries. While there is still an abundance of this material, lithium depletion may lead to increased production of other battery types, like sodium-ion batteries [22]. Lithium batteries are also able to be recycled, easing the pressure of mining and processing new material [23].

As one of the common metals used in battery manufacturing, nickel is another resource to monitor. While not renewable, nickel is also recyclable, so proper recycling habits can help prevent mass loss of material. Both lithium batteries and items containing nickel begin the recycling process by separating the specific metals. Once all materials are separated, they can be cleaned and purified, and they are ready for the next use [23].

Conclusion

The batteries for electric vehicles provide many solid improvements, as well as setbacks compared to previous gas vehicles. Lack of exhaust from the electric vehicle itself is a great step for the environment, but the mineral-intense manufacturing process presents a drawback. To offset this drawback, good recycling habits will also help lessen the impact of electric vehicle batteries.

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