How "Green" Is the Green Electric Vehicle

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Abstract. In a time of climatic crisis, an electric car may be the best option for a customer living in urban area. There are many more benefits of owning an electric car in this thriving age of technology. For example, "Green" credential is the most beneficial feature of an electric car. These cars are eco-friendly with zero carbon emission as they are powered by electricity. As an electric car runs on clean energy source, it emits zero toxic gas, reducing the environmental pollution. Also, the usage of lithium battery illustrates a potential opportunity for reducing global warming. However, this potential opportunity might not result in a way of what the world wants, and it might even reverse the effect of reduction for global warming. Therefore, the paper remains a critical perspective towards electric vehicles, but it doesn't deny the benefits that electric vehicles might bring to society; the paper examines the connections between electric vehicles and environmental impacts by observing each stage of the life-cycle.

Keywords: electric vehicles · environmental impacts · life-cycle · tradeoffs

1 Introduction

There are times when we are sitting in cars waiting for traffic and wondering about global warming because we are seeing waste heat coming from the exhaust of other people's cars. Fortunately, technological improvements have advanced, and people can purchase a non-exhaust vehicle in the market: electric cars. Electric vehicles are usually known for their main energy source of lithium battery instead of an internal combustion engine from fossil fuel, and the usage of lithium battery illustrates a potential opportunity for reducing global warming. However, this potential opportunity might not result in a way of what the world wants, and it might even reverse the effect of reduction for global warming. In other words, it's worth the time to consider whether electric vehicles are having this potential opportunity through the consideration of the whole life-cycle including production, operation and end of life. Therefore, the paper remains a critical perspective towards electric vehicles, but it doesn't deny the benefits that electric vehicles might bring to society; the paper examines the connections between electric vehicles and environmental impacts by observing each stage of the life-cycle. Finally, the paper ends with a political observation and a question that countries are joining into an "international carbon neutral race", and how can this "race" be a push to electric vehicles.

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2 Production of Electric Vehicles

The first stage is the production of electric vehicles, and this includes both extraction of lithiums and manufacturing of lithiums batteries. Due to the growing demand of global electric vehicles, extraction of lithium ores is increasing at a faster rate. For example, the BloombergNEF shows that "electric vehicles (EVs) currently make up only 3% of car sales worldwide. By 2025 electric vehicles will reach 10% of global passenger vehicle sales, growing to 28% in 2030 and 58% by 2040" [8]. This data supports a potential growth rate in lithium as well since electric vehicles are powered by lithium batteries. Given a potential growth in lithium batteries, it's essential to understand how lithium is being extracted from earth and whether the extraction would impact the environment. There are generally two ways of extracting lithium: a conventional extraction and a hard-rock extraction. In a conventional extraction, lithium is extracted from liquid brine reservoirs that are located beneath salt flats, and the reservoirs mainly located in South America and China. Particularly, a conventional extraction requires "drilling to access the underground salar brine deposits, and the brine is then pumped to the surface and distributed to evaporation ponds" [9]. The hard-rock extraction is to extract lithium from some raw minerals such as spodumene, a lithium rich mineral underground. However, the disadvantage of hard-rock extraction is that it takes a higher energy consumption to extract the same amounts of lithium compared to the conventional way, which the process of hard-rock can run twice the cost of the conventional extraction. With these two general ways of extractions, it's not difficult to see the similarities in terms of how they would impact the environment. The similarities are that they both require large land footprints and consumptions of water for the extraction, and it is harmful to the ecosystem where the extraction is taking place. For example, "in May 2016, dead fish were found in the waters of the Liqi River, where a toxic chemical leaked from the Ganzizhou Rongda Lithium mine. Cow and yak carcasses were also found floating downstream, dead from drinking contaminated water" [6]. This shows an implicit tradeoff of how electric vehicles are made, and this would surprise those people who own an electric vehicle that their cars are not eco-friendly but a threat to the ecosystem. Thus, this means that as the demand for electric vehicles are growing, this would have a chain-effect to impact the ecosystem negatively because of the increasing supply of lithium battery extractions.

Furthermore, it's even more ironic to recognize that not only the extraction of lithium impacts the ecosystem negatively, but also it produces large amounts of greenhouse gases when these lithium ions are manufactured into the batteries. According to Swedish Environment Institute, "the moment an electric car is manufactured up to 17.5 tons of carbon dioxide is emitted by the making of the average electric car battery" [1]. Putting this into perspective, a gasoline car produces about 45 metric tons of carbon dioxide in its whole life cycle. This means that at the moment when an electric vehicle is made, it has already emitted the amount of greenhouse gases that is about one-third of the total emission of a gasoline car. In other words, can you imagine your clean energy electric vehicle is not clean, and at least that is true at the moment when it has just been purchased.

3 Generation of Electricity

As mentioned earlier, we shouldn't deny the benefits that electric vehicles have brought to society when they are driven on roads, which is through the stage of operation. It's correct that electric vehicles don't exhaust, but the question now is where does the electricity come from when they are under operation. For example, the researchers suggested that "average "lifetime" emissions from electric cars are up to 70% lower than petrol cars in countries like Sweden and France, where most electricity comes from renewables and nuclear, and around 30% lower in the UK" [4]. This shows a common misunderstanding that the electric vehicles don't emit any greenhouse gases, which is wrong, because they release their greenhouse gases in an implicit way. This also tells buyers that if they would like to purchase an electric vehicle, they should consider whether their countries or states generate the electricity through renewable sources such as hydropower, solar panels and wind turbines. In particular in the USA, different states have different regulations of generating electricity from renewable sources, which some states have strict rules but some don't, and this would make the differences when it comes to driving electric vehicles. For example, driving electric vehicles in California is equivalent to a 87 miles per gallon gasoline car, but driving EVs in Kansas is equivalent to a 35 miles per gallon gasoline car ("Cleaner Cars from Cradle to Grave"). This example reinforces on an idea that although electric vehicles don't explicitly emit greenhouse gases, we should still be aware of the implicit impacts of emissions to the environment. This also suggests a method when buyers are purchasing electric vehicles that they should consider EVs' implicit fuel economy by looking at the electricity generation sources from where they live, because some states such as Kansa might be in a way more environmental friendly if choosing a higher miles per gallon gasoline car compared to electric vehicles. Furthermore, when we are concerned with the benefits of electric vehicles in the stage of operation, we shouldn't only consider the private electric cars on roads but also electric public transportation such as buses and e-bikes. According to data, "an estimated stock of 350 million electric two/three-wheelers in circulation worldwide, and about half a million electric buses are in circulation worldwide" [7]. Within these circulations of buses and two/three wheelers, the majority of them are registered in China. For example, Shenzhen is one of the marjoy cities in China which has the world's first full electric buses, and electric buses take around 41.7% of the total passengers in public transportation. A case study by researchers in UC Davis has shown that the average annual reductions of carbon emissions from electric buses in Shenzhen is approximately 194,000 tons [2]. If we put this number into a more manageable scale, 194,000 tons of carbon dioxide would be equivalent to 38,725 individuals driving gasoline vehicles for a whole year. Clearly, it shouldn't be too difficult to analyze the benefits of electric vehicles during the stage of operation, and there are already analyses sent to governments worldwide requesting for the subsidy programs for purchasing of electric vehicles. Thus, as long as the primary sources to generate electricity are clean and renewable, there wouldn't be counter arguments against electric vehicles driving on roads.

4 Concern About Lithium Batteries

One last critical issue for electric vehicles' life-cycle is the question of whether their lithium batteries are being managed in a proper way at the end of life. The reason for our concern is that the lithium batteries create not only the environmental problems but also the social problems when we don't manage them well enough. Particularly, one of the social problems is the "thermal runaway", which is a chemical reaction that lithium batteries might have a potential to heat up and explode when they are inappropriately managed in landfills. A journal published in Nature has noted that, "waste of lithium batteries presents a number of serious challenges of scale in terms of the chemical separation processes" [5]. When the scale of lithium batteries is tremendously large, which is around 250,000 tons of discarded batteries in 2017, this means that the waste management requires a lot of labor to disassemble them by hand, since the lithium batteries aren't easily disassembled. After all, waste lithium batteries can explode, so this raises the concerns about the safety of workers because it requires them to be highly concentrated and extremely careful throughout the working hours. One solution to this problem is to replace manual workers with robots, because this could easily decrease the risks that waste lithium batteries pose to human workers. As the article in Nature has mentioned, "importantly, automation could also improve the mechanical separation of materials and components, enhancing the purity of segregated materials efficiently and protect the risk of harm to human workers" [5]. However, challenges still arise when uncertainties arise, for example, when there is no standardization in the development of automotive battery packs, this would increase the uncertainties in the disassembly lines for robots to identify some varieties of batteries. So, this would either result in a slower rate of processing or a functional shut-down, and no matter which result the robots would end up with they would consequently have higher economic costs. Until this point, individuals might wonder if there is a chance to divert automotive batteries packs from landfill. The short answer is that there is a way to recycle automotive batteries, but they aren't worth recycling in the perspective of economics at this point. According to the Sustainable Development scenario, it projects the recycling rates of automotive batteries, which is around 2% in the year of 2025 and 4.5% in the year of 2030 [7]. The reason behind such a low recycling rate is due to the lower costs of making new automotive battery packs compared to the higher costs of reusing them. Since the world would have enough reserves of lithium to supply for about 365 years, this is a large number compared to natural gas and oil, which are around 53 and 50 years of supply. Although the numbers are just approximations because of other variations from the demand side as well, they are still relatively representative to show that lithium is inexpensive in terms of supply. This illustrates the challenges of implementing second-life applications for automotive batteries that they need to compete with the lower costs manufacturing of new automotive batteries, but we know that second-life automotive batteries would win in the long run because we just need to be patient until the reserves for lithium ores are close to running out. Thus, the second-life of lithium batteries would revive when their benefits outweigh the costs in the future, and one powerful force that pushes this to happen is time.

5 Conclusion

"The Japanese government declared the goal of realizing a carbon-neutral, decarbonized society by 2050"; "President Xi Jinping committed his country to achieving carbon neutrality by 2060 at the UN General Assembly"; and "President Joe Biden announced a goal to reach net-zero emissions by 2050 and investments in green infrastructure". Internationally, countries are after each other to begin their way of carbon neutral, and this is a sign for the world to transition from fossil fuels economy towards an energy that is saved to use. The word "saved" should not be interpreted as saved for the humans, but rather it should be interpreted as saved for the environment. When can electric vehicles save the environment? In other words, when can countries have enough electric vehicles to surpass gasoline vehicles? According to Bloomberg New Energy Finance, battery electric vehicles would have an exponential growth rate whereas gasoline vehicles would decrease linearly to time, and the projected data has shown that in the year of 2039, the numbers of electric vehicles would equal to the numbers of gasoline vehicles.

Hence, after the year of 2039, there is a possibility to see the numbers of electric vehicles surpassing the numbers of gasoline vehicles [10]. Of course, not only is the rapid increase of electric vehicles influenced by the transitioning of carbon neutral society, but also there are other areas and sectors that would be impacted positively saving the environment. For example, the "international race" of carbon neutral might have an influence on people's behavior, and people might increase an awareness on what they would be driving on roads, which would eventually induce people to purchase more electric vehicles. This illustrates that the greater awareness people would have, the larger impacts that countries can push on carbon neutral, causing a reinforcing loop in a positive way. Therefore, when individuals consider purchasing an electric vehicle, they should ponder on an idea that they aren't just buying a vehicle taking them one place to the others, but instead they are purchasing a "saving" for the future quality of environment or an "entrance ticket" for the future carbon-free society.

In conclusion, the paper offers an idea that electric vehicles aren't as clean as we initially thought from the whole life-cycle analysis such as production, operation and end of life, and they are damaging the environment implicitly. However, this doesn't mean that we should deny the benefits of electric vehicles overall, and we should be objective towards the implementation of it especially under operation in both private and public. Finally, countries' political force might become a crucial element that pushes the tradeoffs of this implementation to a positive point of view a little more, because if we observe a long run carbon neutral as a societal goal, then this would change our opinion towards an expensive electric vehicle and increase our awareness to protect the environment in the long run as well. So, why not start from buying an electric car?

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