Alternative energy electric Vehicles (EV) Essay #3

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A concern for fossil fuel consumption, resources, and environmental sustainability has piqued the interest of worldwide demand for cleaner and more economical energy usage in both transportation and industrial affairs (Holmberg & Erdemir, 2019). One alternative energy choice in the transportation industry that has increased in popularity and worldwide applications is electric cars. Providing that energy stored in batteries for electric cars is supplied from renewable resources, an increase in electrification of the transportation industry has proven to be a huge step in eliminating adverse environmental stressors caused by fossil fuel-powered vehicles (Holmberg & Erdemir, 2019). Electric cars have both reduced operating costs and do not require fossil fuels to operate, which drastically lowers CO_2 emissions and has less environmental impact than traditional internal combustion engine (ICE) vehicles (Holmberg & Erdemir, 2019). Considering energy as our most important resource, the ability to utilize it effectively and efficiently remains a significant issue.

As it stands, ICE vehicles dominate the market at 99% of all driving systems currently in use (Holmberg & Erdemir, 2019). With traditional vehicles that run on fossil fuels, 20% of ICE energy is used to move the vehicle while the other 80% is lost to friction (Holmberg & Erdemir, 2019). Quantifiable effects of average operating costs, CO_2 emissions, and energy usage can be accurately calculated in all passenger vehicles on a global scale (Holmberg & Erdemir, 2019). Statistical data gathered from research suggests that 25% of all energy consumption globally is lost to interacting surfaces in relative motion, where 87% is accounted towards friction and the other 13% for remanufacturing due to wear down of equipment (Holmberg & Erdemir, 2019). Furthermore, the annual economic loss because of this is upwards of 3 million dollars in all societal sectors and accounts for over 8,000 metric tons of CO_2 emissions per year (Holmberg & Erdemir, 2019).

Lithium-ion battery-electric cars have less energy loss due to lower thermal conditions from the lack of heat and high engine temperatures, including less friction. Electric vehicles (EVs) use 5% of their energy for heating and cooling, braking systems, cabin ventilation, and lights (Holmberg & Erdemir, 2019). EVs lose 10% of their energy from charging and discharging with 6% being recovered from the braking system (Holmberg & Erdemir, 2019). Power from electronics and engine usage in EVs combine for a total of 11% energy loss from the core and stray load, stator and rotor resistance, windage, and friction (Holmberg & Erdemir, 2019). When comparing passenger vehicles of similar makes and models, the global average of an ICE vehicle has 22% energy efficiency whereas EVs have over three and a half times more at 77% (Holmberg & Erdemir, 2019). To put all this data into perspective, switching from fossil fuels to renewable energy sources in EVs would reduce the global share of energy production loss from friction by more than 60% (Holmberg & Erdemir, 2019). Moreover, CO_2 emissions in life cycle analyses that range from manufacturing, maintenance, driving, and recycling from ICE vehicles account for 224 grams per kilometer (Holmberg & Erdemir, 2019). EVs have around 4.5 times less at 56 g/km if the energy source is from solar photovoltaics (PV) and geothermal, and 50 g/km if the source is from wind, nuclear, biomass, hydro, or concentrated solar power systems (CSP) respectively (Holmberg & Erdemir, 2019).

While the benefits of electromobility are both promising and crucial for environmental sustainability, transitioning to this technology has several disadvantages. EVs require exergy intensive parts such as the power module, high voltage battery, electric drive, and electromechanical brake servo (Iglesias-Émbil et. al., 2020). Furthermore, technology to produce these parts requires 2.5 to 4 times the quantities of elements than that of ICE vehicles and utilizes both scarce and costly minerals that need to be extracted (Iglesias-Émbil et. al., 2020). Obtaining minerals for EVs can also carry harsh social and environmental repercussions, although lesser than that of fossil fuels. In addition, advancements in technological applications with a larger required number of abundant materials such as nickel, steel, and aluminum may prove challenging in the future of global EV adoption due to worldwide increases in metal demands in other sectors (Iglesias-Émbil et. al., 2020). Metals that are labeled as critical from a supply risk viewpoint such as cobalt, antimony, palladium, lithium (not considered scarce but issues with scaling in economic demands), gold, and tantalum are often more than double that found in ICE vehicles (Iglesias-Émbil et. al., 2020). Supply constraints and rarity of materials used to produce EVs also promote increased upfront costs of these vehicles, often making lower operating costs insufficient on a total cost basis when compared to ICE vehicles (Iglesias-Émbil et. al., 2020). Moreover, the material used to make EVs could cause future reserve shortages with increased societal adoption, dramatically increasing the price even more (Castelvecchi, 2021).

Another challenge faced with EVs that outweighs similar issues associated with ICE vehicles including minimizing the usage of strategic metals is reusing, remanufacturing, and recycling parts (Castelvecchi, 2021; DeRousseau et. al., 2017). This problem is more specifically with the battery, which contains an abundance of valuable minerals particularly located in the cathodes that are associated with performance (Castelvecchi, 2021; DeRousseau et. al., 2017). A major concern with reusing EV batteries after the life span of the vehicle is the liability risk involved for the car manufacturers that discourages secondary applications; however, solutions to this issue are developing rapidly (DeRousseau et. al., 2017). Successful secondary applications such as potential energy storage could prove beneficial on small and large scales to help supply the increased demand for electricity as the economy shifts toward more use (DeRousseau et. al., 2017). Due to the high density and contents of lithium-ion batteries, they can provide extra electricity to the grid providing more balance and reducing the carbon footprint of renewable energy substantially (DeRousseau et. al., 2017). This will provide significant cost benefits by charging at night when peak energy use is low and discharging during the mornings and evenings when peak energy use is high (DeRousseau et. al., 2017). In addition, this can create incentives for owners to receive extra money through the distribution of owned electricity back to the grid in the same way as people who own solar panels at home (DeRousseau et. al., 2017). They are also considered fast assets for frequency regulation in alternating currents that can help eliminate potential damage and blackouts (DeRousseau et. al., 2017).

The shift from ICE vehicles to material-intensive electrical systems in EVs will require tens of kilograms of elements not readily available (Castelvecchi, 2021). According to research, the average lithium-ion battery pack in EVs can contain 8kgs of lithium, 14 kgs of cobalt, 20 kgs of manganese, and 35 kgs of nickel which requires high-cost pure oxygen atmospheres to extract (Castelvecchi, 2021). Lithium-ion batteries have decreased in price and increased in performance since 1991 by more than 97% per kilowatt-hour (Castelvecchi, 2021). However, obtaining minerals such as lithium and cobalt are extensive in energy or water usage, pose serious concerns relating to the health of workers and the environment, and even correlate to child labor (Castelvecchi, 2021; DeRousseau et. al., 2017). Furthermore, the traditional recycling methods of pyrometallurgy requiring high heat energy and the other hydrometallurgy, which requires large amounts of water with fewer yields on the purity of metals recovered, are not ideal (Castelvecchi, 2021; DeRousseau et. al., 2017). These methods are often more costly than mining and destroy the less valuable materials such as lithium in the process (Castelvecchi, 2021; DeRousseau et. al., 2017). One approach to mitigate issues surrounding materials used in batteries is to replace problematic minerals such as cobalt and nickel with disordered rock salts (Castelvecchi, 2021).

The advantages of this will reduce the need for more expensive and scarce minerals subsequently improving the environmental and humanitarian impacts of EVs without sacrificing performance (Castelvecchi, 2021).

Batteries are considered hazardous waste that must be properly disposed of and several EV metals in lithium-ion batteries are more costly to recycle than mine, making them less economically attractive (Castelvecchi, 2021). A big proponent of this is the way batteries are currently being constructed with individual modules being assembled into packs that are typically glued and welded together (Castelvecchi, 2021). Because of this issue, nations such as China have implemented regulated government policies with financial incentives for battery companies to source recycled materials for future use (Castelvecchi, 2021). Statistical data shows that China's largest company can recycle 120,000 tons of batteries per year equivalent to over 200,000 cars, where most of the critical metals are successfully recovered (Castelvecchi, 2021). However, under President Joe Biden, despite support for EV manufacturing and improved recycling regulations, no policies have been implemented in the US outside of existing legislation (Castelvecchi, 2021). Several options are being considered such as barcodes to help distinguish what elements are present in the battery, ultrasound to separate cathode materials for efficient recycling, and future designs that make them easier to take apart (Castelvecchi, 2021). A more positive aspect of these batteries is their lifespan reaching upwards of 20 years, which often exceeds that of the vehicle allowing for reuse in other smaller applications such as stationary energy storage as mentioned above, boats, and houses (Castelvecchi, 2021; DeRousseau et. al., 2017).

The biggest obstacles faced with more EV implementation and worldwide acceptance are the distance EVs can travel, the lack of infrastructure with recharge stations causing 'range anxiety,’ and the amount of time it takes to re-power the vehicle to full capacity (Kley et. al., 2011). Some data using longitudinal perspective suggests multiple places such as Germany cannot replace ICE vehicles with EVs equipped with standard batteries in typical travel behaviors (Mallig et. al., 2016). Evidence inhibits EV usage at high levels of 87% of the population, or 84% if minor restrictions or adaptations to driving norms are considered (Mallig et. al., 2016). Given that the battery amounts to most of the cost of EVs, increasing their capacity would result in a less than desirable price making it a more niche market (Mallig et. al., 2016). Moreover, the average battery range on a full charge typically ranges from 180 miles to 250 miles depending on several varying factors greatly limiting mobility when compared to average ICE vehicles (Mallig et. al., 2016). Consequently, these facts make battery technology a key role in future economic efficiency and success.

Recharging EV batteries is allotted in 3 levels depending on amperage, voltage, and kilowatts (kW) of power. Lower levels with kW ratings between just over 1 to 20 are more common, cost-efficient, and can be utilized at home, but can take anywhere from several hours to over a day to fully charge a typical EV (Kley et. al., 2011). Level 3 direct current (DC) and alternating current (AC) charging utilize the largest amount of voltage, amps, and kW power allowing a fully depleted EV battery to reach a full charge in as little as 15 minutes in higher-end models (Kley et. al., 2011). However, these charging stations are not available for home use and have high costs for both customers and manufacturing (Kley et. al., 2011). Furthermore, charge times pose a problem when compared with ICE vehicles that can be fully fueled in as little as a few minutes at gas stations that outnumber charge stations by over 3.5 times the amount in the US alone (Kley et. al., 2011). While the disadvantages of EVs are complex, there is huge support within various global sectors to improve all facets of this technology to a point of reaching the goal of net-zero carbon emissions by the year 2050.

After evaluating the data on EVs, I would purchase a 2022 all-electric Jaguar 1-Pace. This sports utility vehicle (SUV) has an All-Wheel Drive system with Adaptive Surface Response, All-Surface Progress Control, and low-traction that help the car adapt to and safely navigate various surfaces including rain, snow, and ice (Jaguar USA, 2021). It also features a heat pump that reduces the use of the battery by harvesting heat from the outside of the vehicle that is then transferred into the vehicle via the heating and ventilation system(Jaguar USA, 2021). Furthermore, it’s premium light-emitting diode (LED) headlights provide greater visibility at night which is important when driving in areas with abundant wildlife and few streetlights (Jaguar USA, 2021). All these features would be beneficial when owning a vehicle in Montana, where we are often met with harsh weather conditions and wildlife crossing. Moreover, it holds six airbags, Blind Spot Assist, adaptive cruise control, and a battery that is wrapped in a strong enclosure of aluminum and steel which ensures the safety of the driver as well as the passengers (Jaguar USA, 2021).

Other desirable features of the 2022 all-electric Jaguar 1-Pace include luxury seating, acoustic laminated glass to limit noise from entering the inside of the vehicle, pre-heating, and pre-cooling of the vehicle via the smartphone app, and spaciousness on the inside along with storage on the outside via 25.3 cubic feet of cargo space (Jaguar USA, 2021). These features make for a comfortable ride with space to store items such as luggage. It also contains a navigation system that offers live traffic updates, a 3D surround sound system, and a stolen vehicle locator; all of which make for an enjoyable and secure road-trip experience (Jaguar USA, 2021). Although these features are nice, the fact that this vehicle is all-electric could pose potential problems living in Montana due to charging limitations and total travel distance. Furthermore, fossil fuels are still required to make the electricity to power vehicles such as the Jaguar 1-Pace. This provides a challenge of replacing the methods used for creating EVs to utilizing non-finite resources in the future to achieve desired global environmental sustainability through phasing out fossil fuels completely.

The 2022 Jaguar 1-Pace can travel up to 222 miles when fully charged (Jaguar USA, 2021). However, Montana has a lot of open roads with few charging stations in between destinations. Another obstacle faced is the speed of charging EVs which depends on the source of the power supply. A full charge can often take hours making it inconvenient on longer road trips, especially compared to a gas vehicle such as my 2017 Dodge Ram 1500 which takes minutes to fill. A wall-mounted charger can be purchased and installed at home specifically for the Jaguar 1-Pace (Jaguar USA, 2021). Unfortunately, when it comes to long-distance traveling, gas stations far outnumber charging stations in Montana currently and for the near future, which would make driving the Jaguar 1-Pace challenging. Despite this concern, the Jaguar 1-Pace has 512lb-ft of torque while the 2017 Dodge Ram 1500 with a V-8 engine and a 5.7-liter unit has 410lb-ft of torque (Jaguar USA, 2021; MotorTrend, 2021). Therefore, the Jaguar 1-Pace can climb steep grades and reach higher speeds with more ease and effectiveness than my current vehicle. A towing hitch cannot be purchased or used on the 1-Pace compared to my truck, but that is not a feature I currently use. The horsepower (hp) of this EV is comparable with the Dodge Ram 1500 holding 395 hp and the Jaguar 1-Pace holding 394 hp (Jaguar USA, 2021; MotorTrend, 2021). The Jaguar 1-Pace has a sleek look to it which is appealing; however, it has less storage capacity compared to the Dodge Ram 1500 (Jaguar USA, 2021; MotorTrend, 2021) so looks might be traded for space.

Overall, the Jaguar 1-Pace would be an ideal vehicle for short-distance driving in Montana (no more than 100 miles one way). It has the necessary features to drive in various weather conditions, added features to keep the vehicle warm and comfortable, a sleek look, and a navigation system. In comparison to my Dodge Ram 1500, the Jaguar 1-Pace has less storage space and total travel distance but seems to measure up in every other category such as torque, luxury features, horsepower, and an identical warranty of 5-years/60,000 miles (Jaguar USA, 2021; MotorTrend, 2021). Considering these statistics, I would keep my current ICE vehicle as well out of necessity for longer excursions while using the EV for in-town transportation, until future improvements are made in Montana's EV-friendly infrastructure. Doing this would still reduce my carbon footprint. It would often remain my vehicle of choice, as most of my day-to-day driving necessities are well within its range. Choosing an EV as my primary mode of transportation will significantly improve environmental sustainability. However, more technological advancements in alternative energy are still needed to eliminate fossil fuels.

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